DOT/FAA/CT-85/10

FAA TECHNICAL CENTER
Atlantic City Airport
N.J. 08405

KRASH 85 User's Guide — Input/Output Format

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Prepared by
Lockheed-California Company
Burbank, California

July 1985
(Revised March 1986)
Users Manual

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U.S. Department of Transportation
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16. Abstract

This document describes program KRASH as modified under Contract DTFA03-84-C-00004. The updated version is denoted KRASH85. This document is a User's Guide and defines the input and output formats appropriate for KRASH85.

Features that are incorporated into KRASH85 include:

- An improved plastic hinge moment algorithm
- Gear-oleo metering pin coding
- Load-interaction curves
- An expanded initial conditions subroutine (combined with NASTRAN)
- A comprehensive energy balance
- Center of gravity (c.g.) displacement, velocity, acceleration and force time histories
- Revised vertical beam orientation coding
- Provision to save data for post-processing i.e., acceleration, mass location and forces
- Provisions to input preprocessed data
- A corrected uncoupled KR curve unloading/reloading algorithm
- Provisions to define a tire spring (remains normal to the ground plane)
- Provisions to number the masses to an arbitrary sequence
- An option to compute section shear and moment distributions

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FOREWORD

This report was prepared by the Lockheed-California Company under Contract DTFA03-84-C-00004. The report contains a description of the effort performed as part of Tasks II, III and IV and covers the period from January 1984 to September 1984. The work was administered under the direction of the Federal Aviation Administration with L. Neri acting as Technical monitor.

The program leader was Gil Wittlin of the Lockheed-California Company. M. A. Gamon and W. L. LaBarge of the Lockheed-California Company refined program KRASH. P. Rohrer of the Lockheed-California Company provided valuable computer programming support. The Lockheed effort was performed in the Flutter and Dynamics Department.

TECHNICAL SUMMARY

This document describes program KRASH as modified under Contract DTFA03-84-C-00004. The updated version is denoted KRASH85. This document is a User's Guide and defines the input and output formats appropriate for KRASH85.

Features that are incorporated into KRASH85 include:

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TABLE OF CONTENTS

TABLE OF CONTENTS

LIST OF FIGURES

LIST OF FIGURES

LIST OF TABLES

EXECUTIVE SUMMARY

Program KRASH, originally developed under Federal Aviation Administration sponsorship for predicting the response of general aviation airplanes to an impact environment, has been enhanced to include features that would facilitate the modeling of transport category airplanes. This document is the User's Guide which defines the input and output formats appropriate for this new version of Program KRASH known as KRASH 85.

SECTION 1

INTRODUCTION

Program KRASH, developed under a previous Federal Aviation Administration (FAA) sponsored contract DOT-FA75-WA3707 has been in the public domain since 1979. In subsequent years changes to enhance its usage have occurred. Recently, KRASH has been applied to modeling transport airplanes for impact conditions. Many of the recent program changes that have occurred are designed to facilitate modeling transport airplanes. The following modifications have been incorporated into KRASH85 and used recently to model transport category aircraft:

- Improved plastic hinge moment algorithm
- Gear oleo metering pin
- Load interaction curves
- Expanded Initial Condition Subroutine
- Arbitrary numbering of lumped mass points

Other modifications provide general enhancement capability and include:

- Comprehensive energy balance
- Computation of c.g. time histories
- Revised vertical beam orientation coding
- Post Processing of data, i.e., acceleration, mass location and forces
- Corrected uncoupled KR curve unloading/reloading algorithm

In addition, miscellaneous coding corrections have been made. The current version is denoted KRASH85.

This document is the User's Guide and is limited to a description of the input-output format for KRASH85.

SECTION 2

USER'S GUIDE

2.1 OVERALL KRASH85 ANALYSIS SYSTEM

The overall KRASH85 analysis system consists of two separate KRASH programs called KRASHIC and KRASH85, plus a NASTRAN program denoted herein as MSCTRAN. The NASTRAN program used in this system is MSC/NASTRAN Version 63 (Aug 1, 1983). KRASHIC and MSCTRAN are used only if balanced initial conditions are required; KRASH85 is the normal KRASH time-history program. If KRASHIC and MSCTRAN are not used, then at time zero the beams in the analytical model will all have zero internal deflections and loads. The model will be located just above the ground and in the proper attitude, as specified in the input data. This initial balance is acceptable for certain types of problems, primarily those in which the aerodynamic loads on the vehicle are zero. For that situation, the lumped masses in the model are all accelerating downward at 1g (free-falling), and the internal beam loads and deflections are actually zero.

If nonzero aerodynamic forces are present, then the initial beam loads and deflections are not zero. Nevertheless, execution of KRASH85 by itself will automatically set the beam loads and deflections at zero. If this is done with nonzero aerodynamic forces, the system will be out of balance at time zero. In this situation, the dynamic response will be the result of two phenomena:

- Dynamic response to the ground impact
- Dynamic response to the initial imbalance

The latter response is not desired, and can obscure the desired response or confuse the interpretation of the output data. The proper solution of this problem requires that the analytical model be in equilibrium at time zero with nonzero internal beam loads and compatible deflections.

This is essentially a straightforward static loads analysis problem. NASTRAN is used to solve the statics problem, and KRASHIC is used to read KRASH85 input data and convert it into NASTRAN Executive Case Control and Bulk Data Decks. Figure 2-1 shows a flow diagram for the overall KRASH85 analysis system. The options available to the user include the following:

1. Run step 1 only (program KRASHIC)
2. Iterate steps 1 and 2, N times (user-specified)
3. Iterate steps 1 and 2, N times, then run step 3 (KRASH85)
4. Run step 3 (KRASH85) only

The most general case is option 3. The iterations are required for the following reasons. The static solution used in MSCTRAN is Rigid Format 24, which is a small deflection linear static analysis. This method actually assumes zero deflections for the purposes of calculating transformation matrices for transforming beam loads from beam element axes to the global axis system, which in this case are airplane axes. Therefore, if the deflections from MSCTRAN are used to relocate the KRASH85 mass points, the KRASH85 calculated beam loads will be proper in beam axes, but when resolved to mass axes will yield a system that is out of balance (since KRASH85 does not assume the deflections are zero when calculating the transformation matrices)

The solution to this problem is to iterate steps 1 and 2, using the calculated deflections from MSCTRAN to relocate the mass and node points in KRASH at each step. Satisfactory convergence is achieved after about six iterations, and additional accuracy can be achieved by using up to ten iterations. Beyond ten iterations, no further improvement in accuracy can be achieved due to the limitations in the number of digits that are written to the data sets that form the input and output of MSCTRAN.

The KRASH analysis system shown in figure 2-1 is implemented through Job Control Language (JCL). A job submittal using option 3 with six iterations causes a total of 13 sequential jobs to be executed (6 KRASHIC, 6 MSCTRAN and 1 KRASH85). While this may sound rather expensive, a typical case

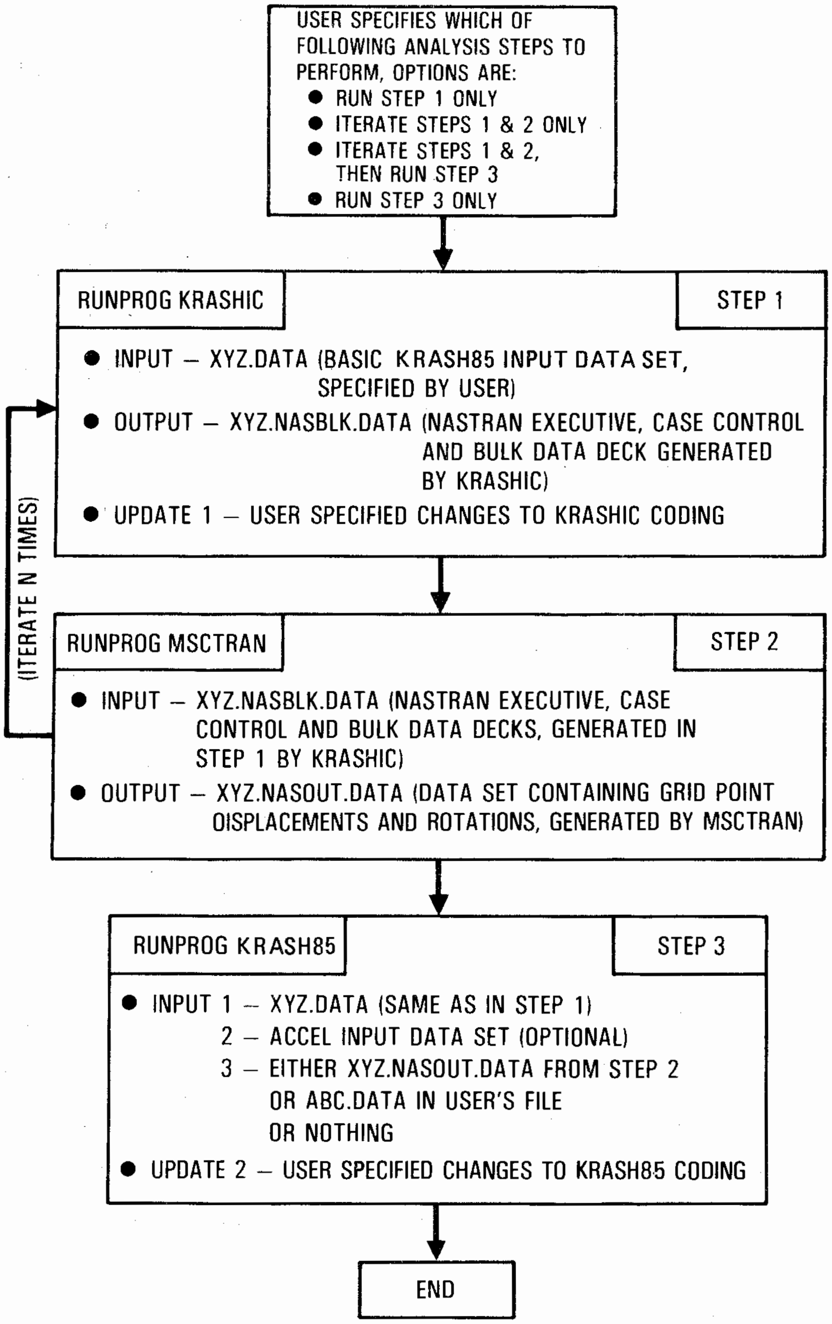

FIGURE 2-1. OVERALL KRASH85 ANALYSIS SYSTEM

(21 mass/27 beam, ½ airplane model) requires only about seven seconds per iteration on an IBM 370/3081, so that the iterated balanced loads can be determined in less than one minute. The JCL is set up so that data sets XYZ.NASBLK.DATA and XYZ.NASOUT.DATA are generated and named automatically, so the process is essentially invisible to the user.

Step 3 (KRASH85) can be executed separately using option 4. When this is done, the user has a choice of what to do for initial conditions. He can specify any data set in his library, or use nothing at all. The latter corresponds to the mode of execution for prior versions of KRASH. Once an initial condition data set (XYZ.NASOUT.DATA) has been generated, the user can execute step 3 only while specifying XYZ.NASOUT.DATA for initial conditions. This will give a valid initial balance as long as modifications to the basic data set (XYZ.DATA) are restricted to items that do not affect the initial balance.

The static loads problem could have been solved entirely within program KRASH, avoiding the complexity of achieving the system shown in figure 2-1 with JCL. However, the technique chosen has the advantage of automatically generating a NASTRAN model from a given KRASH Model. Since XYZ.NASBLK.DATA is a complete NASTRAN input data set in the user's library, the user can easily edit this data set to exercise other NASTRAN capabilities. Examples of other NASTRAN features that could prove useful include eigenvalue calculations and model plotting.

Figure 2-2 is a copy of the informaton displayed on a computer terminal during an option 3 run submittal. The items enclosed in rectangular brackets are the user responses. These are now discussed in detail. Some of the comments are of necessity applicable only to the Lockheed IBM 370/3081 installation, but are included to give some perspective on an actual application.

User Response	Description
runprog krashi x(1)	This is the initial command to invoke the Krash analysis system in Figure 2-1.

```
runprog P6489 x(1)

ENTER TIME

10

ENTER LINES

50

WOULD YOU LIKE EXPRESS, STANDARD
OR DEFERRED(VERNIGHT) TURNAROUND
FOR YOUR JOB? ENTER E, S OR D
 d

Enter number

1   run KRASHIC only
2   iterate KRASHIC and MSCTRAN only
3   iterate KRASHIC and MSCTRAN, then run KRASH85
4   run KRASH85 only

3

Enter name of input data

b720 iciter data

Enter the number of times to cycle through
                   KRASHIC and MSCNASTRAN

10


print execution results only for
      the last iteration?. (Y/N)


y


are you using B720.ICITER.NASOUT.DATA
   with the input data for the 1st iteration? (Y/N)


n

KRASHIC ITERATION #1

If temporary source changes then enter name
    of PAN updata data set.
    If none hit enter.

kic.kvb.data

Suppress compile listing ? (Y/N)

y


KRASHMSC ITERATION # 1
KRASHIC ITERATION # 2
KRASHMSC ITERATION # 2
```

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 1 OF 2)

```
KRASHIC ITERATION # 3
KRASHMSC ITERATION # 3
KRASHIC ITERATION # 4
KRASHMSC ITERATION # 4
KRASHIC ITERATION # 5
KRASHMSC ITERATION # 5
KRASHIC ITERATION # 6
KRASHMSC ITERATION # 6
KRASHIC ITERATION # 7
KRASHMSC ITERATION # 7
KRASHIC ITERATION # 8
KRASHMSC ITERATION # 8
KRASHIC ITERATION # 9
KRASHMSC ITERATION # 9
KRASHIC ITERATION # 10
KRASHMSC ITERATION # 10
               KRASH84
is this a checkpoint/restart run?  (Y/N)
n

If temporary source changes then enter name of
     update data set
     If not then hit enter
k83.icrc.data

HIT "RETURN" KEY IF NO DATA SET:
(A) enter name of 2nd input data set of MASS ACCELERATIONS
    DSA

(b) enter name of output data set of MASS ACCELERATIONS
    DSB

(c) enter name of MASS and/or NODE POINT DISPLACEMENTS
                          (GRAPHICS POST PROCESSOR DATA)
    DSC

How many copies of the printed output do you want?
1
SUPPRESS COMPILE LISTING ? (Y/N)
y
JOB E434367L SUBMITTED BY USER E434367
READY
```

FIGURE 2-2. SAMPLE KRASH85 JOB SUBMITTAL (SHEET 2 OF 2)

User Response	Description
10	Time limit for run = 10 minutes (actual execution time was less than three minutes)
50	Output print limited to 50000 lines (actual output is 21000 lines, about 1.5 inches thick).
d	Overnight (deferred) turnaround requested. (For runs less than 10 minutes, express turnaround is allowed. Results available within one to two hours).
3	Option 3 is chosen.
B720.ICITER.DATA	Basic KRASH85 input data set. This corresponds to XYZ.DATA in figure 2-1.
10	Number of iterations of steps 1 and 2.
y	Printout of KRASHIC and MSCTRAN is suppressed for the first nine iterations. Only the results for the last iteration are printed. Considerable output print will be generated if the results for all iterations are printed. (y = yes)
n	It is possible to start the first iteration with an existing data set of NASTRAN output deflections. For example, five iterations could be run at one time, and five more at a later time. This option was not invoked for this example. (n = no)
kic.kvb.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASHIC. If no revisions are specified, then hit carriage return (CR).
y	A compiled listing of the subroutines changed in the previous step can be obtained. In the example, the listing is suppressed. (y = yes)
-	The terminal displays KRASHMSC ITERATION #1, etc., as the JCL for the sequential runs is being generated.
n	The checkpoint/restart capability of KRASH85 is not used for this run. (n = no)

User Response	Description
k83.icrc.data	This is the name of a PANVALET update data set which is used to revise the source code for KRASH85. If no revisions are specified, then hit carriage return (CR).
DSA DSB DSC	In the example shown, the CR was hit for each of these, so no data sets were specified. DSA, DSB, and DSC are indicated here to illustrate where these are specified in the input. DSA, DSB, and DSC are described in the input format description.
1	One copy of the output print requested.
y	A compiled listing of the subroutines of KRASH85 that are revised can be obtained. In this example, the listing is suppressed. (y = yes)

The KRASH85 analysis system described herein is capable of achieving a balanced set of initial conditions <u>only</u> for the situation where the airplane starts completely off the ground. If any part of the airplane is initially in contact with the ground (any external springs initially deflected), the current code cannot balance the airplane.

2.2 INPUT

The input data format is described in detail in this section and is shown in table 2-1 and figure 2-3. Table 2-1 gives a quick overview of the input data sequence, while figure 2-3 is a complete layout of the input data format. The data discussed in this section correspond to XYZ.DATA in Section 2.1. Unless otherwise specified, all quantities are input to inch, pound, second, and radian units. Two formats are used for the majority of the data; 7E10.0 for fixed-point and scientific-notation input, and I5 for integers. As an exmaple of the former, the number 126.08 can be input in the following ways:

		1	2	6	.	0	8		
		1	2	6	.		8		

	1	.	2	6	0	8		E	2
	1	2	6	0	8	.	E	-	2

TABLE 2-1. KRASH INPUT FORMAT SEQUENCE

Card Sequence No.(s)	Required (R) or Optional (O)	Card Type Identifier	Identifier is Specified on Card No.	General Description of Data
10-170	R	–	–	Title, case control, initial conditions
200	R	NM	40	Mass data
300	0	NNP	40	Node point data
400	0	NTAB	70	Acceleration transfer correspondence data
500	0	NMSAV	80	Mass acceleration save data
600	0	NNPSAV	80	Node point acceleration save data
700-800	0	NSP	40	External spring data
900	R	NB	40	Internal beam data
1000	0	NMTL	40	Material data
1100	0	NPIN	40	Beam pinned-end and plastic hinge data
1200	0	NUB	40	Unsymmetrical beam data (axial only)
1290-1500	0	NOLED	40	Oleo type beam element data
1600	R	–	–	Internal beam damping ratio
1700	0	ND	40	Non-standard internal beam damping ratios
1800-1900	0	NLB	40	Nonlinear beam data (KR tables)
2000	0	MVP	40	Mass penetration volume definition
2100	0	NDRI	40	Dynamic Response Index (DRI) definitions
2200	0	NVCH	40	Volume change data
2300	0	NVBM	50	Non-standard maximum positive beam deflections.
2400	0	NVBMN	50	Non-standard maximum negative beam deflections.
2500	0	NFBM	50	Non-standard maximum positive beam loads
2600	0	NFBMN	50	Non-standard maximum negative beam loads
2700	0	NSCV	60	Sign convention vectors for load-interaction curves
2800-3020	0	NLIC	60	Load-interaction curve data
3100	0	NHI	50	Non-zero mass angular momenta, lift constant, or inertia cross products
3200	0	NPH	50	Non-zero initial mass orientation Euler angles
3300	0	NAERO	50	Mass aerodynamic data
3400-3500	0	NACC	40	Mass acceleration or load input time-histories
3600	0	NKM	50	Direct input of beam stiffness matrices
3700-3800	0	NPLT	140	Position plot data
3900	0	NMEP	140	Mass point printer plot data
4000	0	NNEP	140	Node point printer plot data
4100	0	NBFP	140	Beam loads printer plot data
4200	0	NBDP	140	Beam deflection printer plot data
4300	0	NSTP	140	Beam stress ratio printer plot data
4400	0	NSEP	140	External spring load/deflection printer plot data
4500	0	NENP	140	Beam strain/damping energy printer plot data
4600	0	NDRP	140	DRI printer plot data
4700	R	–	–	End of data set card

GENERAL PURPOSE DATA SHEET

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A DIVISION OF LOCKHEED CORPORATION

TITLE: KRASH85 INPUT FORMAT

PREPARED BY | DATE | CHECKED BY | DATE | JOB NO. | GROUP | PAGE 1 OF 7
W.O. | EWA | ID | SEQ

TITLE CARD 10
TITLE CARD 20
12345678901234567890123456789012345678901234567890123456789012345678901 2 30
DUMMY *
NM | NSP | NB | NLB | NNP | NPIN | NUB | NORI | NOLEO | NACC | MVP | NVCH | NMTL | ND 40
DUMMY *
NVBM | NFBM | NVBMN | NFBMN | NKM | NHI | NPH | NTOL1 | NTOL2 | NTOL3 | NSC | NIC | NAERO | NBOMB 50
DUMMY *
NSCV | NLIC | NWRGRA | NBAL | ICD | ICITER 60
DUMMY *
(CSIN) ▨ (RNIN) NTAB 70
(CSOUT) ▨ (RNOUT) NMSAV NNPSAV NDTSAV NWRFLG NDTGRA 80
DUMMY *
CASEIN ▨ RUNIN MSECIN 90
CASEOUT ▨ RUNOUT MSCOUT(1) MSCOUT(2) — — — — 100
DUMMY *
DP/DT DT TMAX PLOWT FCUT RUNMOD 110
DUMMY *
BLANK CARD 120

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 1 OF 7)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
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PAGE 2 OF 7

TITLE:

PREPARED BY | DATE | CHECKED BY | DATE | JOB NO. | GROUP | W.O. | EWA | ID | SEQ

DUMMY											*
NSF	NTF	NDE	NSPD	NED	NS	NRP	NIMP	NBC		130	
DUMMY											*
NMEP	NNEP	NBFP	NBDP	NSTP	NSEP	NENP	NDRP	NPLT	NPFCT	140	
DUMMY											*
XGDOT	YGDOT	ZGDOT								150	
PPR	QPR	RPR								160	
PHIPR	THEPR	PSIPR	XGIN	ZGIN	BETA	RHO				170	
DUMMY	(NM CARDS FOLLOW)										*
WGT(I)	XDP(I)	YDP(I)	ZDP(I)	XI(I)	YI(I)	ZI(I)	ID			200	
DUMMY	(NNP CARDS FOLLOW)										
MNP(I)	INP(I)	XNPDP(I)	YNPDP(I)	ZNPDP(I)						300	
DUMMY	(NTAB CARDS FOLLOW)										
IS_{NEW}	MS_{NEW}	LS_{NEW}	IS_{OLD}	MS_{OLD}	LS_{OLD}	TSH				400	
DUMMY	(NMSAV CARDS FOLLOW)										
☒	ISAV	MFL_1	MFL_2	MFL_3	MFL_4	MFL_5	MFL_6	MFL_7	MFL_8	MFL_9	500
DUMMY	(NNPSAV CARDS FOLLOW)										
MNPSAV	INPSAV	$NPFL_1$	$NPFL_2$	$NPFL_3$	$NPFL_4$	$NPFL_5$	$NPFL_6$	$NPFL_7$	$NPFL_8$	$NPFL_9$	600

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 2 OF 7)

GENERAL(,RPOSE DATA SHEET

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A DIVISION OF LOCKHEED CORPORATION

PAGE 3 OF 7

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP
				W.O.	EWA

ID | SEQ

DUMMY	(2X NSP CARDS FOLLOW)								
M I K	XLBAR	XMU	XKE	FPLOW	GFLEX	ITIRE			700
SI	SA	SB	SF	FSPOI	FSPOF	CDAMP			800
DUMMY	(NB CARDS FOLLOW)								*
M I N J	AA	XJ	IYY	IZZ	XIQ	Z1 Z2	MC		900
DUMMY	(NMTL CARDS FOLLOW								
MC	EE	GG	STENS	SCOMP	SHEAR				1000
DUMMY	(NPIN CARDS FOLLOW)								
M I N J	PYI PZI	PYJ PZJ	SF35	SF26	SF35J	SF26J			1100
DUMMY	(NUB CARDS FOLLOW)								
M I N J	IJUB	DB							1200
DUMMY	(2X NOLEO + 1 + METERING PIN CARDS FOLLOW)								
ALPHAP	NMPTAB								1290
M I N J	EOLEO	FAO	FAA	EXPOLE	YMAX				1300
M I N J	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB			1400
NPTSMP			} REPEAT	NMPTAB	TIMES				1490
YOLEO i	BOLEO i	i=1,..., NPTSMP }							1500
DUMMY	(1 CARD FOLLOWS)								
DAMPC									1600
DUMMY	(ND CARDS FOLLOW)								
M I N J	CBAR								1700

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 3 OF 7)

GENERAL PURPOSE DATA SHEET

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PAGE 4 OF 7

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP	ID	SEQ
				W.O.	EWA		

DUMMY (NLB + CARDS FOLLOW)

M I N J L NP LDP LDP1 1800

XKR_i KR_i $i=1,..,NP$, REPEAT FOR ALL KR TABLES WITH $NP \geq 10$ 1900

DUMMY (1 CARD FOLLOWS IF $MVP \neq 0$)

XN XP YN YP ZN ZP 2000

DUMMY (DRI SPEC. CARD(S) FOLLOW)

I_1 J_1 I_2 J_2 -- -- -- -- I_{NDRI} J_{NDRI} 2100

DUMMY (NVCH CARDS FOLLOW)

I_{1i} I_{2i} I_{3i} I_{4i} I_{5i} I_{6i} I_{7i} I_{8i} 2200

DUMMY (NVBM CARDS FOLLOW)

M I N J VMAX1 VMAX2 VMAX3 VMAX4 VMAX5 VMAX6 2300

DUMMY (NVBMN CARDS FOLLOW)

M I N J VMAXN1 VMAXN2 VMAXN3 VMAXN4 VMAXN5 VMAXN6 2400

DUMMY (NFBM CARDS FOLLOW)

M I N J FMAX1 FMAX2 FMAX3 FMAX4 FMAX5 FMAX6 2500

DUMMY (NFBMN CARDS FOLLOW)

M I N J FMAXN1 FMAXN2 FMAXN3 FMAXN4 FMAXN5 FMAXN6 2600

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 4 OF 7)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
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PAGE	OF
5	7
ID	SEQ

TITLE:

PREPARED BY | DATE | CHECKED BY | DATE | JOB NO. | GROUP | W.O. | EWA

1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80

DUMMY (NSCV CARDS FOLLOW)
(1,1) (1,2) (1,3) (1,4) (1,5) (1,6)
— — — — — — } ISCVEC(J,I) J=1,NSCV (10 MAX) USER INPUT SIGN 2700
(NSCV,1) — — — — (NSCV,6) I=1,6 CONVENTION VECTORS

1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80

DUMMY
IJ K L NLIL ISCN NSMI FSLIC(I) BLLIC(I) WLLIC(I) RUPRAT(I) 2800
FMXLIC(1,I) FMXLIC(2,I) FMXLIC(3,I) FMXLIC(4,I) 2900
(1,1,I) (2,1,I) FLIC(1,1,I) FLIC(2,1,I) I=1,NLIC
(1,2,I) (2,2,I) FLIC(1,2,I) FLIC(2,2,I) 3000

1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80

— — — — } NLIL CARDS
(1,NLIL,I) (2,NLIL,I) FLIC(1,NLIL,I) FLIC(2,NLIL,I)

MXYLIC(K,J,I) K=1,2 J=1,NLIL(I) I=1,NLIC

1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80

WLSMF WLSMA 3010
IJSM1 IJSM2 IJSM3 IJMS4 IJMS5 IJMS6 IJMS7 IJMS8 IJMS9 IJMS10 IJMS11 IJMS12 IJMS13 IJMS14 3020
DUMMY (NHI CARDS FOLLOW)
I LC HEX HEY HEZ XYI YZI XZI NHSY 3100
DUMMY (NPH CARDS FOLLOW)
I PHIDP THEDP PSIDP 3200
DUMMY (NAERO CARDS FOLLOW)

1 5 7 10 15 20 25 30 35 40 45 50 55 60 65 70 73 76 77 80

I CXAIR CYAIR CZAIR CLAIR CMAIR CNAIR 3300

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 5 OF 7)

GENERAL PURPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

PAGE	OF
6	7
ID	SEQ

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP
				W.O.	EWA

DUMMY (NACC + CARDS FOLLOW)

I L NP NCODE 3400

$TIME_i$ $ACCEL_i$ $i=1,..,NP$, REPEAT NACC TIMES 3500

DUMMY (7 x NKM CARDS FOLLOW)

M I N J

K_{11}	K_{12}	K_{13}	K_{14}	K_{15}	K_{16}	
K_{21}	K_{22}	K_{23}	K_{24}	K_{25}	K_{26}	
K_{31}	K_{32}	K_{33}	K_{34}	K_{35}	K_{36}	3600
K_{41}	K_{42}	K_{43}	K_{44}	K_{45}	K_{46}	
K_{51}	K_{52}	K_{53}	K_{54}	K_{55}	K_{56}	
K_{61}	K_{62}	K_{63}	K_{64}	K_{65}	K_{66}	

DUMMY (2 x NPLT CARDS FOLLOW)

NTPL NMPTS ISCLE ☒ XSCALE YSCALE } POSITION PLOT DATA 3700

M1 M2 M3 M4 M5 M6 M7 - - - 3800

DUMMY (NMEP CARDS FOLLOW)

I MP1 MP2 MP3 MP4 MP5 MP6 MP7 MP8 MP9 3900

DUMMY (NNEP CARDS FOLLOW)

M I NP1 NP2 NP3 NP4 NP5 NP6 4000

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 6 OF 7)

GENERAL RPOSE DATA SHEET

LOCKHEED-CALIFORNIA COMPANY
A DIVISION OF LOCKHEED CORPORATION

PAGE 7 OF 7

TITLE:

PREPARED BY	DATE	CHECKED BY	DATE	JOB NO.	GROUP
				W.O.	EWA

```
1   5 7  10   15   20   25   30   35   40   45   50   55   60   65   70  73 7677  80
 DUMMY    (NBFP CARDS FOLLOW)
IJ   BFP1 BFP2 BFP3 BFP4                                                        4100
 DUMMY    (NBDP CARDS FOLLOW)
 IJ  BDP1 BDP2 BDP3                                                             4200
 DUMMY   (NSTP CARDS FOLLOW)
IJ   STP1 STP2 STP3 STP4 STP5                                                   4300
 DUMMY    (NSEP CARDS FOLLOW)
 I    M   SEP1 SEP2                                                             4400
 DUMMY    (NGNP CARDS FOLLOW)
 IJ  ENG1 ENG2                                                                  4500
 DUMMY   (NDRP CARDS FOLLOW)
 J                                                                              4600
END                                                                             4700
```

*DENOTES DUMMY LABEL CARD THAT IS ALWAYS REQUIRED. ALL OTHER DUMMY CARDS ARE NEEDED ONLY IF RESPECTIVE DATA FOLLOWS

FORM 8104-2

FIGURE 2-3. KRASH85 INPUT FORMAT (SHEET 7 OF 7)

Blank columns are treated as zeros. When the E format is used, the exponent must be right justified in the field. With the I5 integer format, the number must be right justified. The sequence numbers shown in columns 77 through 80 are only for reference purposes within this document. The actual data cards can have any numbering scheme, or no numbers at all, as long as the cards are in the proper order.

The following coordinate systems (figure 2-4) are established to facilitate the derivation of equations for the mathematical model. The input data description specifies the appropriate coordinate systems to be used.

- Ground Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point 0 in figure 2-4. The x-axis is positive forward, the y-axis is positive to the right, and the z-axis is positive downward. The xy-plane (z = 0) corresponds to the ground surface. The ground coordinate system is considered an inertial coordinate system for writing the dynamic equations of motion.

- Slope Coordinate System. - This is a right-handed coordinate system fixed in the ground with the origin at point 0 as shown in figure 2-4. The x-axis is positive forward up the slope, the y-axis is positive to the right, and the z-axis is positive downward and perpendicular to the slope. This coordinate system is the same as the ground coordinate system rotated through an angle 'beta', positive clockwise about the ground y-axis. The xy-plane represents a plane inclined at an angle 'beta' with respect to the horizontal ground plane. 'Beta' is a constant input angle that can range from zero to ninety degrees.

- Airplane Coordinate System. - This is a left-handed coordinate system fixed with relation to the airplane with the origin at point H in figure 2-4. The x-axis is positive aft, the y-axis is positive to the left when looking forward, and the z-axis is positive upward. The origin at point H corresponds to zero fuselage station (FS = 0), zero buttline (BL = 0), and zero waterline (WL = 0). This coordinate system is used only to input the location coordinates of the mass points and massless node points since the coordinates of the points are usually available in terms of fuselage station, buttline, and waterline.

- Center-of-Gravity Coordinate System. - This is a right-handed coordinate system fixed with relation to the airplane with the origin at the vehicle c.g., point G. The x-axis is positive forward, the y-axis is positive to the right when looking forward, and the z-axis is positive downward. These axes are parallel to the airplane coordinate system axes.

- Mass Point Coordinate System. - Each mass point has its own right-handed coordinate system fixed with relation to the mass point. The initial orientation of each of these coordinate systems is arbitrary and is specified by means of three input Euler angles for each mass point relating its initial orientation to the center-of-gravity coordinate system since the inertia data are generally available about these axes and the three input Euler angles are zero. The mass point coordinate system is the system used to write Euler's equations of motion for each mass point.

- Beam Element Coordinate System. - This is a right-handed coordinate system with the beam element x-axis along a straight line from the mass point at end 'I' to the mass point at end "j". As the mass points move, the beam element coordinate system changes orientation so that the x-axis is always pointing from the mass point at end 'I' to the mass point at end 'J'. If the beam element connects massless node points which are offset from the mass points, then the beam element x-axis always points from the massless node point rigidly attached to the mass point at end 'I' to the massless node point rigidly attached to the mass point at end 'J'.

  The beam element y-axis and z-axis are mutually perpendicular. The direction of each is arbitrary and is defined internally within the program. The input data are prepared according to the beam element coordinate systems shown in figure 2-5 (page 2-46).

The following is a detailed description of all the input data requirements.

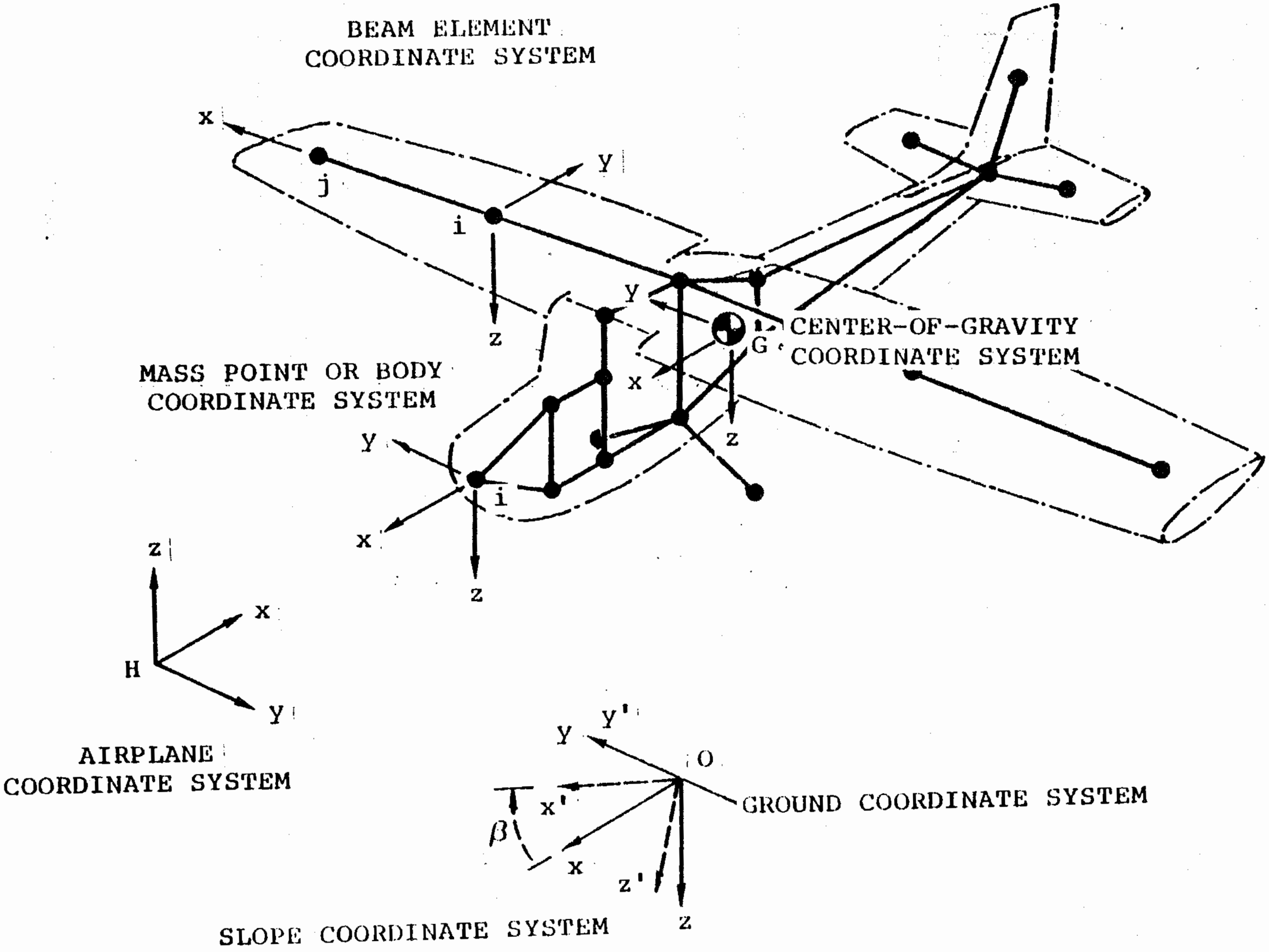


FIGURE 2-4. KRASH85 COORDINATE SYSTEMS

KRASH* INPUT DATA

CARD 0010: TITLE CARD #1

DESCRIPTION: Defines an alphanumeric label which will appear as the first line of heading on each page of KRASH* printed output.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
TITLE1	
SUBSTRUCTURE SECTION IMPACT STUDY	0010

FIELD	CONTENTS
Title1	Alphanumeric Character String

REMARKS:
(1) Required data card; however, it may be blank.
(2) All text material on this card is reproduced at the top of every output page and on every plot.

CARD 0020: TITLE CARD #2

DESCRIPTION: Defines an alphanumeric label which will appear as the second line of heading on each page of KRASH printed output.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
TITLE2	
INITIAL CONDITIONS: 27.5 FPS VERTICAL IMPACT ON RIGID SURFACE	0020

FIELD	CONTENTS
Title2	Alphanumeric Character String

REMARKS:
(1) Required data card; however, it may be blank.
(2) All text material on this card is reproduced at the top of every output page and on every plot.

---

*KRASH refers to KRASH85 in all subsequent input data sheets

CARD 0030: DUMMY CARD

DESCRIPTION: Defines a numeric heading which will appear on each page of the KRASH printout of the input data deck echo.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890	
DUMMY	
123456789012345678901234567890123456789012345678901234567890123456789012	0030

FIELD	CONTENTS
Dummy	Numeric String

REMARKS:
(1) Required data card; however, it may be blank.
(2) Intent of this data card is to aid the user in verifying the field placement of the input data.

NOTE: On figure 2-3 (pages 2-10 through 2-16) there are several dummy cards shown. Dummy label cards preceding data cards 40 through 200 as well as those preceding cards 900 and 1700 are always required. These cards are normally labelled so as to denote the data that follows on the subsequent respective card. The remaining dummy cards are needed only if the data that follows are input. If needed, these dummy cards should be labelled so as to best describe the set of data that follows on the subsequent card(s).

CARD 0040: KRASH MODEL SIZE PARAMETERS

DESCRIPTION: Defines the sizes of the various input parameter data sets for the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

NM	NSP	NB	NLB	NNP	NPIN	NUB	NDRI	NOLEO	NACC	MVP	NVCH	NMTL	ND	☒	
16	10	32	2	6	0	4	0	0	0	0	0	0	1		0040

FIELD	CONTENTS
NM	Number of Mass Points Per 0200-Series Cards (Maximum Allowed is 80)
NSP	Number of External Crushing Springs Per 0700/0800-Series Cards (Maximum Allowed is 40)
NB	Number of Beam Elements Per 0900-Series Cards (Maximum Allowed is 150)
NLB	Number of Beam Element Nonlinear Degrees-of-Freedom Per 1800-Series Cards (Maximum Allowed is 180)
NNP	Number of Massless Node Points Per 0300-Series Cards (Maximum Allowed is 50)
NPIN	Number of Beam Elements Having at Least One Degree-of-Freedom Pinned Per 1100-Series Cards (Maximum Allowed is 150)
NUB	Number of Axially Unsymmetric Beam Elements Per 1200-Series Cards (Maximum Allowed is 150)
NDRI	Number of DRI Beam Elements Per 2100-Series Cards (Maximum Allowed is 150)
NOLEO	Number of Shock Strut Elements Per 1300 and 1400-Series Cards (Maximum Allowed is 20)
NACC	Number of Enforced Acceleration Time History Tables Per 3400/3500-Series Cards (Maximum Allowed is 100 Input Tables, With a Total of 5000 Time Points)
MVP	Reference Mass Point For Volume Penetration Calculations Per 2000-Series Cards (Maximum Allowed is 1)
NVCH	Number of Volumes For Occupiable Volume Change Calculations Per 2200-Series Cards (Maximum Allowed is 5)
NMTL	Number of Non-Standard Beam Element Materials Per 1000-Series Cards (Maximum Allowed is 10)
ND	Number of Beam Elements With Non-Standard Damping Ratios Per 1700-Series Cards (Maximum Allowed is 150)

REMARKS:

(1) Required data card.
(2) All entries are right justified integers.
(3) 'NM' and 'NB' must be nonzero.
(4) Blank entries are read as zero.
(5) See Table 2-1 for a summary of model size parameters.
(6) Format for this card is 14I5.

TABLE 2-2. PROGRAM SIZING CONSTANTS

CONSTANT	MAXIMUM VALUE	DESCRIPTION
NM	80	NUMBER OF MASSES
NSP	40	NUMBER OF EXTERNAL SPRINGS
NB	150	NUMBER OF INTERNAL BEAMS
NLB	180	NUMBER OF NONLINEAR BEAM-DIRECTION COMBINATIONS (KR TABLES)
NHI	80	NUMBER OF MASSES HAVING NON-ZERO He_{x_i}, He_{y_i}, He_{z_i}, I_{xy_i}, I_{yz_i}, I_{xz_i}, OR ℓ_{c_i}
MVP	–	REFERENCE MASS NUMBER FOR VOLUME PENETRATION CALCULATIONS
NVCH	5	NUMBER OF VOLUMES FOR OCCUPIABLE VOLUME CHANGE CALCULATIONS
NDRI	150	NUMBER OF DRI BEAM ELEMENTS
NMTL	10	NUMBER OF NON-STANDARD BEAM MATERIALS
NACC	100	NUMBER OF INPUT ACCELERATION TIME-HISTORY TABLES (TOTAL NUMBER OF TIME POINTS = 5000)
NVBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NVBM) OR NEGATIVE (NVBMN) DEFLECTIONS FOR BEAM RUPTURE. STANDARD VALUE = 100 (inches OF DEFLECTION AND radians OF ROTATION)
NVBMN	150	
NFBM	150	NUMBER OF INTERNAL BEAMS HAVING NON-STANDARD MAXIMUM POSITIVE (NFBM) OR NEGATIVE (NFBMN) FORCES FOR BEAM RUPTURE. STANDARD VALUE = 1E10
NFBMN	150	
NPH	80	NUMBER OF MASSES HAVING NON-ZERO EULER ANGLES ϕ_i”, θ_i”, ψ_i”
ND	150	NUMBER OF INTERNAL BEAMS HAVING DAMPING RATIOS DIFFERENT FROM THAT SPECIFIED ON CARD 1600
NKM	150	NUMBER OF INTERNAL BEAMS FOR WHICH THE FULL 6 x 6 STIFFNESS MATRIX IS DIRECTLY INPUT
NPIN	150	NUMBER OF INTERNAL BEAMS HAVING OTHER THAN FIXED-FIXED END CONDITIONS
NNP	50	NUMBER OF MASSLESS NODE POINTS
NUB	150	NUMBER OF UNSYMMETRICAL BEAMS
NOLEO	20	NUMBER OF SHOCK STRUTS

CARD 0050: KRASH MODEL SIZE PARAMETERS AND CALCULATION FLAGS

DESCRIPTION: Defines the sizes of the various input parameter data sets for the KRASH model and provides for beam element stress and/or failure data calculations.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

NVBM	NFBM	NVBMN	NFBMN	NKM	NHI	NPH	NTOL1	NTOL2	NTOL3	NSC	NIC	NAERO	NBOMB	☒		
0	0	0	0	0	0	0	10	50	100	0	0					0050

FIELD	CONTENTS
NVBM	Number of Beam Elements Having Non-Standard Rupture Positive Deflections Per 2300-Series Cards (Maximum Allowed is 150)
NFBM	Number of Beam Elements Having Non-Standard Rupture Positive Forces Per 2500-Series Card (Maximum Allowed is 150)
NVBMN	Number of Beam Elements Having Non-Standard Rupture Negative Deflections Per 2400-Series Card (Maximum Allowed is 150)
NFBMN	Number of Beam Elements Having Non-Standard Rupture Negative Forces Per 2600-Series Cards (Maximum Allowed is 150)
NKM	Number of Beam Elements For Which 6 x 6 Stiffness Matrix is Directly Input Per 3600 Series Cards (Maximum Allowed is 150)
NHI	Number of Mass Points Having Nonzero Aerodynamic Lift Constant, Angular Momenta, or Cross Products of Inertia Per 3100-Series Card (Maximum Allowed is 80)
NPH	Number of Mass Points Having Nonzero Euler Angles For Rotating the Mass Point or Body Coordinate System Relative to The Center-of-Gravity Coordinate System Per 3200-Series Cards (Maximum Allowed is 80)
NTOL1	Percent Allowable Total Energy Growth Above 100 Percent (Default Value is One (1) Percent)
NTOL2	Percent Allowable Individual Negative Strain, Damping, Crushing and Friction Terms of Respective Totals (Default Value is Ten (10) Percent)
NTOL3	Percent Allowable Individual Mass Energy Deviation Above Zero Percent (Default Value is Thirty (30) Percent
NSC	Flag For Beam Element Stress Calculation: 0 = No 1 = Yes
NIC	Flag For Preliminary Beam Element Failure Load and Deflection Calculations: 0 = No 1 = Yes
NAERO	Number of Masses Having Aerodynamic Data Input Per 3300-Series Card (Maximum Allowed is 80)
NBOMB	Any Nonzero Input Will Override all Energy Growth Error Checks. Run Will Execute to Completion Regardless of Energy Calculations.

REMARKS:

(1) Required data card; however it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) If any of the allowable errors in energy are exceeded, the analysis terminates automatically at that time, and summary tables and printer plots are generated.
(5) Default values for NVBM and NVBMN are 100 inches or radians. Default values for NFBM and NFBMN are 1E10, lbs or in-lbs.
(6) See Table 2-1 for a summary of model size parameters.
(7) It is recommended that NIC = 1 be used each time if complete beam properties are input (0900-series cards).
(8) Format for this card is 14I5.

CARD 0060: KRASH LOAD INTERACTION CURVE (LIC) CONTROL PARAMETERS

DESCRIPTION: Defines the sizes of input parameter data sets for the KRASH model and controls the output of graphics information and specifies the type of initial conditions to be used.

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="8">0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890</td></tr>
<tr><td>NSCV</td><td>NLIC</td><td>NWRGRA</td><td>NBAL</td><td>ICD</td><td>ICITER</td><td></td><td></td></tr>
<tr><td>1</td><td>16</td><td>0</td><td>5</td><td>1</td><td>1</td><td></td><td>0060</td></tr>
</table>

FIELD	CONTENTS
NSCV	Number of User-Specified Sign Convention Vectors, Per 2700-Series Cards, To Be Used in Conjunction With Load-Interaction Curve Data. (Maximum Allowed is 10) NSCV May be Zero.
NLIC	Number of Load-Interaction Curves Per 2800/3000-Series Cards (Maximum Allowed is 40)
NWRGRA	Parameter Which Governs Whether Graphics Data For Postprocessing is Written to The User's Data File. NWRGRA = 0 Results in No Data Being Written to The User's File. Any Nonzero Input Will Result in Mass and Node Point Displacement Time-History Data, Plus Load-Interaction Time-History Data (if NLIC $\neq$ 0), being written to the user's data file, in data set DSC, Defined in JCL.
NBAL	If MSC/NASTRAN is To Be Used For a Static Solution, Then NBAL is The Mass Number That is Constrained to Have Zero Deflections and Rotations.
ICD	Parameter Which Determines Whether an Additional Data Set of Mass and Node Point Static Deflections is To Be Read Following the Basic Input Data Set. ICD = 0 Means That The Additional Data Set is Not Read. Any Nonzero Input Causes The Program to Read The Initial Deflection Data.
ICITER	Parameter Which Determines Whether The Initial Mass and Node Point Deflection Data (ICD $\neq$ 0) is Used To Modify The Input Airplane Coordinates For The Mass and Node Points. ICITER = 0 Means The Initial Static Deflection Data is Not Used to Modify The Mass Coordinates; i.e., The Airplane is Left in Its Undeformed Position. Any Nonzero Value of ICITER Results in The Input Mass Coordinates Being Modified to Reflect The Initial Static Deflections, i.e., The Airplane Assumes The Deformed Shape Corresponding to The Initial Static Load Condition.

REMARKS:

(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) See Section 3.1 for a discussion of the load-interaction curve data; Section 2.1 for a discussion of initial conditions.
(4) Both ICD and ICITER must be either 0 (NACC = 0) or $\neq$ 0 (NACC $\neq$ 0).
(5) To print load interaction curve data at selected interval parameter NDTGRA on card 0080 must $\neq$ 0. See remark (4) page 2-27 for relationship between NDTGRA, TMAX and DT.
(6) For restart cases in which a NASTRAN IC has been run both ICITER and ICD = 1 and the IC data set must be specified.
(7) Format for this card is 6I5.

CARD 0080: ACCELERATION TRANSFER CONTROL PARAMETERS

DESCRIPTION: Defines data for saving mass and mode point accelerations for later use as input data in another run.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

(CSOUT)	☒	(RNOUT)	NMSAV	NNPSAV	NDTSAV	NWRFLG	NDTGRA		
			6	3	10	1	20		0080

FIELD	CONTENTS
(CSOUT)	Not Used
(RNOUT)	Not Used
NMSAV	Number of Masses For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 500-Series Cards (Maximum allowed is 80) See Remark (5).
NNPSAV	Number of Node Points For Which Selected Acceleration Data Will be Saved in Data Set DSB (Identified in JCL), as Specified on 600-Series Cards (Maximum Allowed is 50) See Remark (5)
NDTSAV	Multiple of Integration Time Interval DT at Which Acceleration Data Will be Saved. See Remark (4)
NWRFLG	Parameter Governing Whether Selected Acceleration Data Will be written to User's Data File as Data Set DSB. Any Nonzero Value Will Cause The Data to be Written; NWRFLG = 0 Will Cause The Data Not to be Written, Regardless of The Remaining Input Parameters on This Card.
NDTGRA	Multiple of Integration Time Interval DT at Which Mass and Node Point Displacement Data Will be Written to User's Data File as Data Set DSC (Identified in JCL). This Data is Used For Graphics Postprocessing. NWRGRA on Card 0600 Must be Nonzero For This Data to be Written as DSC in User's Data File. NDTGRA Also Defines The Time Interval For Saving Load-Interaction Data. For The Load Interaction Data, if NWRGRA on Card 0060 is Zero, The Print Output Will Still Contain Time-Histories of All Load Interaction Output Data. If it is Desired to Save This Data in Data Set DSC For Postprocessing, Then NWRGRA Must be Input Nonzero. See Remark (4).

REMARKS:

(1) Required data card; however, it may be blank.

(2) All entries are right justified integers.

(3) See Sections 3.1 and 3.2 for discussions of load-interaction curve data and acceleration transfer control and graphics data.

(4) Both NDTSAV and NDTGRA must be chosen so that less than 100 time cuts are saved for each response quantity. This is satisfied if

$$\begin{pmatrix}\text{NDTSAV}\\ \text{and}\\ \text{NDTGRA}\end{pmatrix} > \frac{\text{TMAX}}{100 * \text{DT}}$$

(5) The total number of response quantities saved (total number of nonzero MFL's and NPFL's on 0500 and 0600 Series Cards) must be less than 100.

(6) Format for this card is (A6, 4X, A10, 5I10).

CARD 0090: RESTART CONTROL PARAMETERS

DESCRIPTION: Defines the identifiers of a previously checkpointed KRASH case and the simulation time from which the KRASH analysis will be restarted.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7		8
12345678	90	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	12	34567890
CASEIN	☒	**RUNIN**	**MSECIN**	☒	☒	☒	☒	☒	
OLEO		1	40						**0090**

FIELD	CONTENTS
CASEIN	Alphanumeric Identifier of Checkpointed Case (Maximum of Eight Characters, Left Justified)
RUNIN	Numeric Identifier of Checkpointed Case
MSECIN	Restart Time – Milliseconds

REMARKS:

(1) Required data card, however, it may be blank.
(2) All numeric entries are right justified integers.
(3) Previously checkpointed case must be resident on mag tape and be accessed via JCL.
(4) Restart time must be included in the KRASH analysis of the previously checkpointed case.
(5) Only nonblank when using restart capability to initiate from a preceding analysis that has been saved.
(6) Format for this card is(A8, 2X, 2I10).

CARD 0100: CHECKPOINT CONTROL PARAMETERS

DESCRIPTION: Defines indentifiers and simulation times for the current KRASH case to checkpoint the analytical results for future restarts.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

CASEOUT	☒	RUNOUT	MSCOUT(1)	MSCOUT(2)	MSCOUT(3)	MSCOUT(4)	MSCOUT(5)	☒	
OLEO		2	40	80	100	120	150		0100

FIELD	CONTENTS
CASEOUT	Alphanumeric Identifier (Maximum of Eight Characters, Left Justified)
RUNOUT	Numeric Identifier
MSCOUT1	Analysis Times at Which Results Will be Saved – Milliseconds

REMARKS:

(1) Required data card; however, it may be blank.

(2) All numeric entries are right justified integers.

(3) JCL must provide mag tape on which results will be saved.

(4) Only nonblank when data are to be saved. A maximum of five times can be saved per analysis.

(5) Format for this card is (A8, 2X, 6I10.0).

KRASH INPUT DATA

CARD 0110: PARAMETERS FOR NUMERICAL INTEGRATION, PLOWING FORCE, ACCELERATION FILTER, AND KRASH EXECUTION MODE

DESCRIPTION: Defines print control, numerical integration time step, analysis time, plowing force time, acceleration filter cutoff frequency, and KRASH execution mode (airplane model and impact condition symmetry).

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

DP/DT	DT	TMAX	PLOWT	FCUT	RUNMOD	☒	☒	
100	0.00001	0.120	0.0	100.0	1.0			0110

FIELD	CONTENTS
DP/DT	Multiple of Numerical Integration Time Interval at Which Output Will be Printed, Right Justified Interger
DT	Fixed Time Step For Numerical Integration – Seconds
TMAX	Maximum Analysis Time – Seconds
PLOWT	Analysis Time at Which Plowing Forces Cease – Seconds
FCUT	Cutoff Frequency of First-Order Filter Applied to Mass Point Translational Accelerations – Hertz (E10.0 Format)
RUNMOD	Flag to Control the Mode of Program Execution as Follows:

RUNMOD	INPUT DATA SET	DATA SET ANALYZED	AIRPLANE MODEL	IMPACT CONDITIONS
0.	Full Airplane	Full Airplane	Unsymmetrical	Unsymmetrical
1.	Half Airplane	Half Airplane	Symmetrical	Symmetrical
2.*	Half Airplane	Full Airplane	Symmetrical	Unsymmetrical

*See remark (5)

REMARKS:

(1) Required data card.

(2) 'DP/DT', 'DT', 'TMAX', and 'RUNMOD' are required inputs.

(3) Blank entries are read as zero.

(4) Entries requiring scientific notation (X.XEXX) should be right justified.

(5) For RUNMOD = 2, image mass number = 100 + mass number.

(6) Suitable values for 'DT' range from 0.00001 to 0.001 seconds. A rule of thumb for selecting a final integration value is the following:

$$DT \leq 0.01/\text{Max. Computed Beam Frequency (Hz).}$$

(7) Nonzero plowing forces act from time = 0 to time = 'PLOWT'. For time > 'PLOWT' the plowing forces are set to zero.

(8) Suitable values for 'FCUT' range from fifty to eighty-five percent of the actual test filter cutoff frequency. Eighty-five percent is commonly used.

(9) Format for this card is (110, 5E10.0).

CARD 0120: VARIABLE INTEGRATION PARAMETERS

DESCRIPTION: Define parameters for numerical integration with variable time step.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

IVAR	EL	EU	RATMIN	RATMAX	☒	☒	☒	
1	0.01	0.10	0.6	2.0				0120

FIELD	CONTENTS
IVAR	Flag For Type of Numerical Integration With Variable Time Step as Follows (Right Justified Integer):

IVAR	TYPE OF NUMERICAL INTEGRATION WITH VARIABLE TIME STEP
0	None
1	Tolerance Based on Six Linear and Angular Velocities of Each Mass Point
2	Tolerance Based on Energy

EL	Maximum Tolerance
EU	Minimum Tolerance
RATMIN	Integration Time Step Factor if Tolerance > 'EU'
RATMAX	Integration Time Step Factor if Tolerance < 'EL'

REMARKS:

(1) Required data card, but it should be blank as the variable integration algorithm is not currently operational.
(2) Blank entries are read as zero.
(3) Format for this card is (I10, 4E10.0).

CARD 0130: PRINT OUTPUT CONTROL

DESCRIPTION: Defines flags to control the printout of results, KRASH model size parameters, and allowable errors in energy for terminating the analysis.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

NSF	NTF	NDE	NSPD	NED	NS	NRP	NIMP	NBC					
1	1	1	1	1	1	1	1	1					0130

FIELD	CONTENTS
NSF	Flag For Printout of Beam Element Strain Forces
NTF	Flag For Printout of Beam Element Total Forces – Strain and Damping
NDE	Flag For Printout of Beam Element Deflections
NSPD	Flag For Printout of External Crushing Spring Loads and Deflections
NED	Flag For Printout of Energy Distribution Per Mass Point, Beam Element, and External Crushing Spring
NS	Flag For Printout of Beam Element Stresses
NRP	Flag For Printout of Mass Point Displacement, Velocity, and Accelerations
NIMP	Flag For Printout of Mass Impulses
NBC	Flag For Printout of Beam Component Loads

REMARKS:

(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) Print control flags: 0 = No, 1 = Yes.
(5) At time zero or the first time cut of a restart, all print will be output regardless of the entries on this card.
(6) Format for this card is 9I5.

CARD 0140: PRINTER PLOT CONTROL PARAMETERS

DESCRIPTION: Defines the type and number of time history printer plots and defines the number of mass point position (structure deformation) printer plots.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

NMEP	NNEP	NBFP	NBDP	NSTP	NSEP	NENP	NDRP	NPLT	NPFCT	☒	☒	☒	
21	0	3	0	0	0	2	1	2	20				0140

FIELD	CONTENTS
NMEP	Number of Mass Points Having Time History Printer Plots Per 3900-Series Cards
NNEP	Number of Massless Node Points Having Time History Printer Plots Per 4000-Series Cards
NBFP	Number of Beam Elements Having Load Time History Printer Plots Per 4100-Series Cards
NBDP	Number of Beam Elements Having Deflection Time History Printer Plots Per 4200-Series Cards
NSTP	Number of Beam Elements Having Stress Time History Printer Plots Per 4300-Series Cards
NSEP	Number of External Crushing Springs Having Time History Printer Plots Per 4400-Series Cards
NENP	Number of Beam Elements Having Strain and/or Damping Energy Time History Printer Plots Per 4500-Series Cards
NDRP	Number of DRI Mass Points Having Time History Printer Plots Per 4600-Series Cards
NPLT	Number of Mass Point Position (Structure Deformation) Printer Plots Per 3700/3800-Series Cards
NPFCT	Print Time Factor For Which Mass Point Position (Structure Deformation) Plots Are Generated

REMARKS:

(1) Required data card; however, it may be blank.
(2) All entries are right justified integers.
(3) Blank entries are read as zero.
(4) Blank or zero entries do not generate printer plots.
(5) Mass position plots occur at time = 0, and at intervals equal to NPFCT x DP/DT x DT.
(6) Format for this card is 10I5.

KRASH INPUT DATA

CARD 0150: INITIAL AIRPLANE LINEAR VELOCITIES

DESCRIPTION: Defines the initial airplane linear velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7		8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	12	34567890
XGDOT	YGDOT	ZGDOT	☒	☒	☒	☒	☒	
0.0	0.0	360.0						0150

FIELD	CONTENTS
XGDOT	Initial Fore-and-Aft Velocity of Airplane, Positive Forward
YGDOT	Initial Lateral Velocity of Airplane, Positive Right
ZGDOT	Initial Vertical Velocity of Airplane, Positive Down

REMARKS:

(1) Required data cards; however, it may be blank.
(2) Velocity units are inches per second.
(3) Blank entries are read as zero.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Format for this card is 3E10.0.

CARD 0160: INITIAL AIRPLANE ANGULAR VELOCITIES

DESCRIPTION: Defines the initial airplane angular velocity components with respect to the ground coordinate system.

FORMAT AND EXAMPLE:

0 1	2	3	4	5	6	7		8
1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	1234567890	12	34567890
PPR	QPR	RPR	☒	☒	☒	☒	☒	
0.0	0.0	0.012						0160

FIELD	CONTENTS
PPR	Initial Airplane Roll Velocity, Positive Right Wing Down
QPR	Initial Airplane Pitch Velocity, Positive Nose Up
RPR	Initial Airplane Yaw Velocity, Positive Nose Right

REMARKS:

(1) Required data card; however, it may be blank.
(2) Angular velocity units are radians per second.
(3) Blank entries are read as zero.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Format for this card is 3E10.0.

CARD 0170: MISCELLANEOUS AIRPLANE INITIAL CONDITIONS

DESCRIPTION: Defines the initial airplane attitude Euler angles and the initial airplane linear position with respect to the ground coordinate system and defines the ground plane slope angle.

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="9">0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890</td></tr>
<tr><td>PHIPR</td><td>THEPR</td><td>PSIPR</td><td>XGIN</td><td>ZGIN</td><td>BETA</td><td>RHO</td><td>☒</td><td></td></tr>
<tr><td>0.0</td><td>0.001</td><td>0.0</td><td>0.0</td><td>0.0</td><td>45.0</td><td>1.1463E-07</td><td></td><td>0170</td></tr>
</table>

FIELD	CONTENTS
PHIPR	Initial Airplane Roll Euler Angle, Positive Right Wind Down – Radians
THEPR	Initial Airplane Pitch Euler Angle, Positive Nose Up – Radians
PSIPR	Initial Airplane Yaw Euler Angle, Positive Nose Right – Radians
XGIN	Fore-and-Aft Distance of Airplane Initial CG Position Relative to the Basic Position Calculated in the Initial Condition Subroutine, Positive Aft – Inches
ZGIN	Vertical Distance of Airplane Initial CG Position Relative to the Basic Position Calculated in the Initial Condition Subroutine, Positive Up – Inches
BETA	Ground Plane Slope Angle, Positive Up – Degrees
RHO	Air Density Used for Calculating Aerodynamic Loads (NAERO ≠0), Pound-Sec^2/In^4

REMARKS:

(1) Required data card; however, it may be blank.

(2) Blank entries are read as zero.

(3) Normally, 'XGIN' and 'ZGIN' are input as zero and the KRASH initial conditions subroutine positions the airplane relative to ground.

(4) If it is desired to have the airplane impact only on the slope and not on the horizontal ground, a large value of ZGIN may be input (1000 inches). This will move the airplane upward ZGIN above the horizontal ground, and simultaneously move it forward so that it is almost contacting the slope. The normal initial position for the airplane is wedged into the juncture of the horizontal ground and the slope as explained in Volume I, Section 1.3.15.

(5) Values of 'BETA' range from zero to ninety degrees (horizontal to vertical impact surfaces).

(6) Entries requiring scientific notation (X.XEXX) should be right justified.

(7) If NSP = 0 (no external springs), ZGIN is the distance from the ground plane to the airplane CG, positive up.

(8) Formats for this card is 7E10.0.

KRASH INPUT DATA

CARDS 0200: MASS POINT DATA

DESCRIPTION: Defines the weight, location coordinates, and mass moments of inertia for each of the mass points in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

WGT	XDP	YDP	ZDP	XI	YI	ZI	ID	
103.0	50 0	20.0	33.0	12.5	3.7	12.5	21	0200

FIELD	CONTENTS
WGT	Weight – Pounds
XDP	Fuselage Station Coordinate, Positive Aft – Inches
YDP	Buttline Coordinate, Positive Left – Inches
ZDP	Waterline Coordinate, Positive Up – Inches
XI	Roll Mass Moment of Inertia – Inch * Pound * Second**2
YI	Pitch Mass Moment of Inertia – Inch * Pound * Second**2
ZI	Yaw Mass Moment of Inertia – Inch * Pound * Second**2
ID	Mass Point Number

REMARKS:

(1) 'NM' on card 0040 specifies the number of these cards for input.

(2) Set of data (NM ≠ 0) is preceded by one dummy label card. (Always required.)

(3) Blank entries are read as zero.

(4) The location coordinates are defined in a left-handed coordinate system.

(5) All three mass moments of inertia must be nonzero.

(6) Mass moment of inertia cross products may be defined on the 3100-series of cards.

(7) Entries requiring scientific notation (X.XEXX) should be right justified.

(8) Mass point number (ID) must be greater than zero or less than 100. Mass numbers must be unique and can be input in any order. If ID for any mass point is left blank, all mass points will automatically be numbered sequentially in the order of input.

(9) For RUNMOD = 2, the Image mass point number will equal the mass point number plus 100.

(10) Formats for this card is 7E10.0, I2.

KRASH INPUT DATA

CARDS 0300: MASSLESS NODE POINT DATA

DESCRIPTION: Defines for each of the massless node points in the KRASH model the location coordinates and the mass point number to which each is rigidly attached.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

MNP	INP	XNPDP	YNPDP	ZNPDP	☒	☒	☒	☒	
1	12	10.0	−12.0	33.0					0300

FIELD	CONTENTS
MNP	Massless Node Point Number (Right Justified Integer)
INP	Mass Point Number (Right Justified Integer)
XNPDP	Fuselage Station Coordinate, Positive Aft – Inches
YNPDP	Buttline Coordinate, Positive Left – Inches
ZNPDP	Waterline Coordinate, Positive Up – Inches

REMARKS:

(1) Optional data card(s).
(2) 'NNP' on card 0040 specifies the number of these cards for input.
(3) 'MNP' and 'INP' must be nonzero.
(4) Blank entries are read as zero.
(5) The massless node point number is determined by taking each mass point and numbering the node points attached to it 1, 2, 3, . . . etc. There is no limit on the number of node points that may be connected to a single mass point.
(6) The location coordinates are defined in a left-handed coordinate system.
(7) User should not place a node point on the center line for a RUNMOD = 2 condition. Program will not generate a connection across this point. User can place node point slightly off center, if necessary.
(8) Generally used to model regions wherein rigid connections exist (i.e., seat. engine) or where multiple behavior is being represented by different elements.
(9) Entries requiring scientific notation (X.XEXX) must be right justified.
(10) Format for this card is (2I5, 3E10.0).

CARDS 0400: ACCELERATION TRANSFER DATA

DESCRIPTION: Defines the correspondence between mass/node point numbers from a previous model for which acceleration data was saved, and the current model which is to use the acceleration data as input forcing functions.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

ISNEW	(MSNEW)	LSNEW	ISOLD	MSOLD	LSOLD	TSH		
3		4	6	3	4	.003		**0400**

FIELD	CONTENTS
ISNEW	Mass Number in Current (New) Model That Will be Driven by an Acceleration Table Saved in Data Set DSA (defined in JCL)
(MSNEW)	Not Used (Coding Does Not Allow Driving a Node Point With an Input Acceleration)
LSNEW	Direction for Which Table Read From Data Set DSA Will Drive Mass ISNEW LSNEW: 1 = XACCEL 4 = PDOT 2 = YACCEL 5 = QDOT 3 = ZACCEL 6 = RDOT
ISOLD	Mass Number in Previous (OLD) Model, The Acceleration From Which Will be Used to Drive Mass ISNEW in The Current Model
MSOLD	Node Point Number in Previous (OLD) Model. Coding Allows Driving a Mass in The Current Model With an Acceleration From a Node Point in The Previous Model
LSOLD	Direction of Acceleration Saved in Prior Model to be Used to Drive the Current Model. It is Not Necessary for LSOLD = LSNEW; i.e., an XACCEL From a Previous Model Can Drive a ZACCEL in The Current Model LSOLD: 1 = XACCEL 4 = PDOT 7 = XACC FILTERED 2 = YACCEL 5 = QDOT 8 = YACC FILTERED 3 = ZACCEL 6 = RDOT 9 = ZACC FILTERED
TSH	Time Shift Applied to Data From Previous Model (Stored in DSA) Before Using in Current Model. This Allows User to Apply a "Downstream" Response From Previous Model as Input to The Current Model, Which Starts at t = 0 $t_{NEW} = t_{OLD} - TSH$

REMARKS:

(1) Optional data card(s).

(2) NTAB on card 0070 specifies the number of these cards for input.

(3) Data set DSA, generated from a previous run, must be in the user's data file in order to use the acceleration transfer data. The actual data set name for DSA is specified in the JCL.

(4) A different TSH can be specified for each table used.

(5) Filtered accelerations from a previous model can be used to drive the current model. (LSOLD = 7, 8 or 9).

(6) Format for this card is (6I5, IE10.0).

CARDS 0500: MASS ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines mass numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

0	1	2	3	4	5	6	7	8			
12345678901234567890123456789012345678901234567890123456789012345678901234567890											
☒	ISAV	MFL1	MFL2	MFL3	MFL4	MFL5	MFL6	MFL7	MFL8	MFL9		
	15	0	0	1	0	1	1	0	1	0		**0500**

FIELD CONTENTS

ISAV Mass Number For Which Acceleration Data From Current Run Will be Stored in User's Data File in Data Set DSB

MFL1 – MFL9 Flags Defining For Which Directions (1-9) Acceleration Date is to be Saved in Data Set DSB. Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History For The Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS:

(1) Optional data card(s).
(2) NMSAV on Card 0080 specifies the number of these cards for input.
(3) Date set DSB is specified in the JCL.
(4) The acceleration data is saved at time intervals of NDTSAV, specified on Card 80.
(5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
(6) Format for this card is (5X, 10I5).

CARDS 0600: NODE POINT ACCELERATION SAVE PARAMETERS

DESCRIPTION: Defines node point numbers and directions for saving acceleration time-history data.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

MNPSAV	INPSAV	NPFL1	NPFL2	NPFL3	NPFL4	NPFL5	NPFL6	NPFL7	NPFL8	NPFL9			
3	15	0	0	1	0	1	1	0	1	0			**0600**

FIELD	CONTENTS
ISAV, MNPSAV	Mass and Node Point Number for Which Acceleration Data From Current Run Will be Stored in User's Data File in Data Set DSB
NPFL1– NPFL9	Flags Defining for Which Directions (1-9) Acceleration Date is to be Saved in Data Set DSB. Input Either 1 or 0 for Each Item; 1 Denotes Save The Acceleration Time-History for The Indicated Direction. Directions 1-9 Correspond to The Description of LSOLD on Cards 0400.

REMARKS:

(1) Optional data card(s).
(2) NNPSAV on Card 0080 specifies the number of these cards for input.
(3) Date set DSB is specified in the JCL.
(4) The acceleration data are saved at time intervals of NDTSAV, specified on Card 80.
(5) NWRFLG on Card 80 must be nonzero to write the acceleration data into date set DSB.
(6) Format for this card is 11I5.

CARDS 0700: EXTERNAL CRUSHING SPRING PARAMETERS

DESCRIPTION: Defines the attach point, direction, length, ground coefficient of friction, bottoming spring rate, plowing force, and ground flexibility for each of the external crushing springs in the KRASH model.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

M	I	K	XLBAR	XMU	XKE	FPLOW	GFLEX	ITIRE	☒	☒	
	11	3	10.0	0.3	20000.0	0.0	0.0	1			0700

FIELD	CONTENTS
M	Massless Node Point Number (Right Justified Integer)
I	Mass Point Number (Right Justified Integer)
K	Degree-of-Freedom in Which External Crushing Spring Acts Where 1, 2, 3 Correspond to the X, Y, Z Directions in the Mass Point Coordinate System (Right Justified Integer)
XLBAR	Free Length of Spring Either Positive or Negative in the Mass Point Coordinate System – Inches
XMU	Impact Surface Coefficient of Friction. Values of Between 0.35 to 0.60 are Appropriate For Structure to Ground Contact.
XKE	Bottoming Spring Rate – Pounds Per Inch
FPLOW	Plowing Force – Pounds
GFLEX	Impact Surface Flexibility – Inches Per Pound
ITIRE	Defines spring that remains normal to contact surface

REMARKS:

(1) Optional data card(s).

(2) 'NSP' on card 0040 specifies the number of these cards for input.

(3) Blank entries are read as zero.

(4) The free length of the external crushing spring is arbitrary; however, the value generally represents the actual depth of the crushable structure.

(5) A value of zero for the impact surface flexibility (GFLEX) represents a rigid surface. A flexibility value of 0.00036 in/lb is an approximate representation in KRASH for soil. having a CBR ≃4 and moisture content of ≈30 percent.

(6) Entries requiring scientific notation (X.XEXX) must be right justified.

(7) If ITIRE = 1 external spring remains normal to contact surface. Use only for tire representation in K = 3 direction. If Beta > 0 tire spring remains normal to sloped surface. Not coded to account for transition from flat to sloped surface.

(8) Format for this card is (I2, I3, I5, 5E10.0, I5).

CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS

DESCRIPTION: Defines four deflection points, two load values and one damping value for each external crushing spring in the KRASH model.

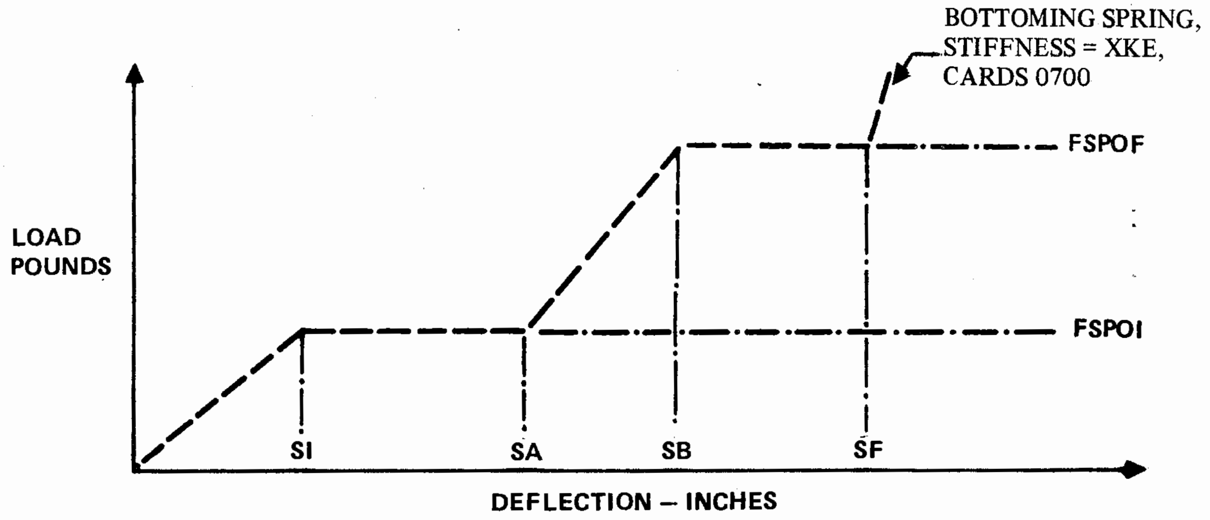
FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

SI	SA	SB	SF	FSPOI	FSPDF	CDAMP	☒	
0.1	1.0	3.5	5.0	10000.0	25000.0	.08		0800

FIELD	CONTENTS
SI	Deflection Point at Which First Linear Region Ends and First Nonlinear Region Begins – Inches
SA	Deflection Point at Which First Nonlinear Region Ends and Second Linear Region Begins – Inches
SB	Deflection Point at Which Second Linear Region Ends and Second Nonlinear Region Begins – Inches
SF	Deflection Point at Which Second Nonlinear Region Ends and Linear Bottoming Begins – Inches
FSPOI	Constant Load Between Deflection Points SI and SA – Pounds
FSPOF	Constant Load Between Deflection Points SB and SF – Pounds
CDAMP	Critical Damping Ratio. Acceptable Range is .02 to .10

REMARKS:
(1) 'NSP' on card 0040 specifies the number of these cards for input.
(2) These load-deflection cards must be ordered to correspond with the 0700-series cards of external crushing spring data.
(3) The general shape of the load-deflection curve is as follows:



CARDS 0800: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION AND DAMPING PARAMETERS (Continued)

(4) External spring damping in program KRASH is computed as:

$$2 * \text{CDAMP} * \sqrt{(\text{FSPOI}/\text{SI}) * \text{WGT} / 386.4}$$

where WGT is the weight for mass i.

(5) Entries requiring scientific notation (X.XEXX) should be right justified.
(6) Format for this card is 7E10.0.

CARDS 0900: BEAM ELEMENT PROPERTIES

DESCRIPTION: Defines the end points and cross-sectional properties for each beam element in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

M	I	N	J	AA	XJ	IYY	IZZ	XIQ	Z1	Z2	MC	
	2	1	5	0.5	0.0	3.67	1.54	0.0	0.0	0.0	4	900

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number at End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
AA	Cross-Sectional Area – Inches**2.
XJ	Torsional Stiffness Inertia – Inches**4
IYY	Cross-Sectional Area Moment of Inertia About Beam Element Y-Axis For Bending In X-Z Plane – Inches**4
IZZ	Cross-Sectional Area Moment Of Inertia About Beam Element Z-Axis For Bending In X-Y Plane – Inches**4
XIQ	Cross-Sectional Shape Factor Relating Torsional Shear Stress To The Applied Moment – 1/Inches**3
Z1	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Z-Direction – Inches
Z2	Distance From The Neutral Axis To The Extreme Fibers In The Beam Element Y-Direction – Inches
MC	Material Code Number (Right Justified Integer)

REMARKS:

(1) "NB" on card 0040 specifies the number of these cards for input.
(2) Blank entries are read as zero.
(3) At least one beam element must be defined.
(4) The order of these data cards determines the beam element number.
(5) If "XJ" is input as zero, KRASH will automatically compute a value for "XJ" as the sum of "IYY" and "IZZ".
(6) The beam element coordinate system depends on the geometric orientation as shown in Figure 2-5.
(7) "XIQ", "Z1", and "Z2" are used only for stress calculations (See Section 1.3.17 in Volume I).
(8) The torsional stress parameter "XIQ" is equal to the shape factor "1/Q" used in Roark's formulas for stress and strain (Reference 4).
(9) KRASH has ten standard materials internally defined as shown in Table 2-2.
(10) Entries requiring scientific notation (X.XEXX) should be right justified.
(11) Format for this card is (2(I2, I3), 5E10.0, 2F5.0, I2).

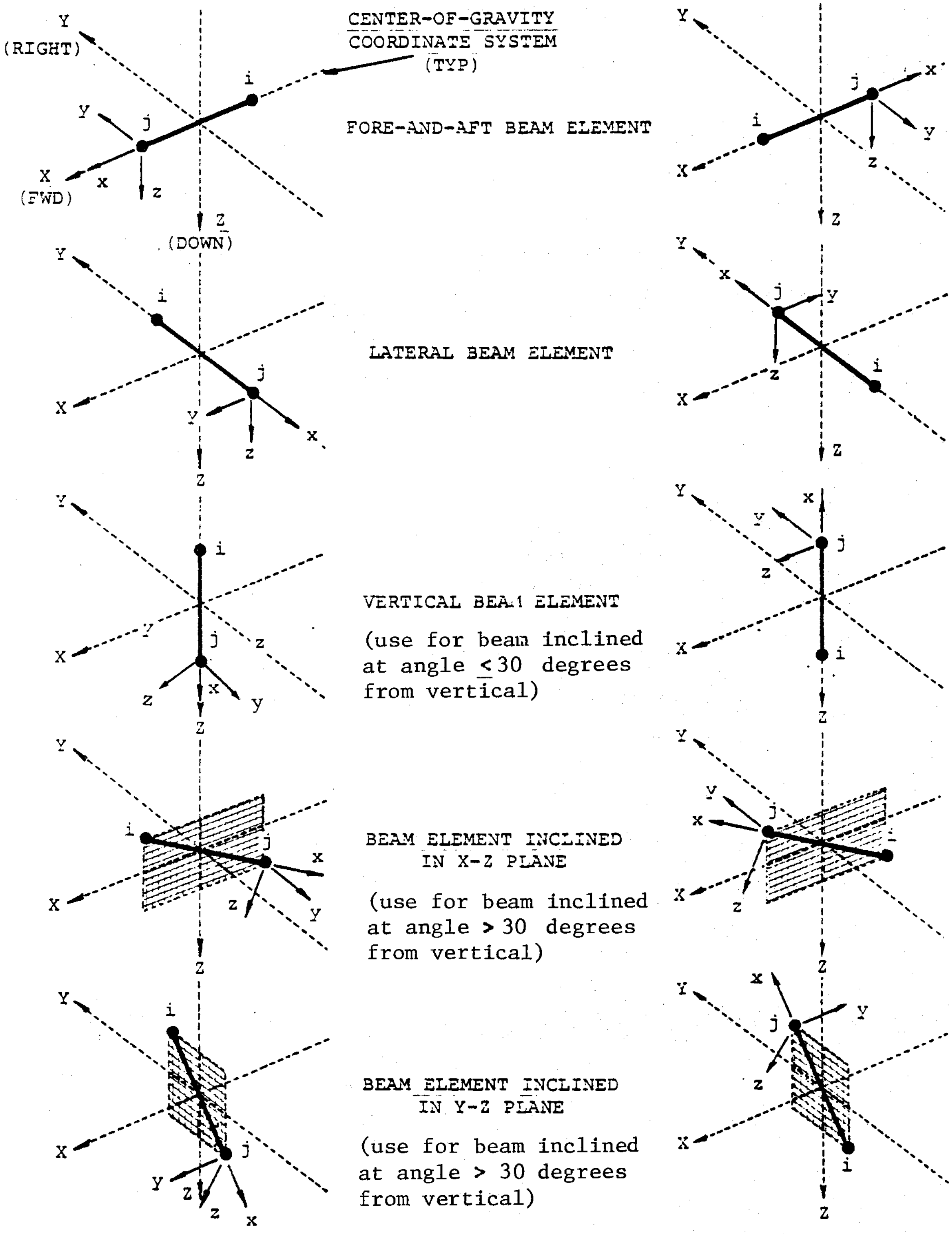


FIGURE 2-5. BEAM ELEMENT COORDINATE SYSTEM ORIENTATIONS

TABLE 2-3. STANDARD MATERIAL PROPERTIES

MC	MATERIAL	MODULUS OF ELASTICITY (PSI)	MODULUS OF RIGIDITY (PSI)	TENSILE STRESS (PSI)	COMPRESSIVE STRESS (PSI)	SHEAR STRESS (PSI)
1	4130 STEEL	30.0E6	11.0E6	75000	75000	37500
2	6150H STEEL	30.0E6	11.0E6	205000	205000	80000
3	300–SERIES STAINLESS STEEL	28.0E6	12.5E6	70000	46000	36000
4	2024–T3 ALUMINUM	10.5E6	4.0E6	47000	39000	22000
5	6061-T3 ALUMINUM	10.0E6	3.8E6	35000	34000	17000
6	8195–T4 CAST ALUMINUM	10.0E6	3.8E6	16000	16000	17000
7	LOW MODULUS MATERIAL	1.0E6	0.4E6	16000	16000	17000
8	ZERO TORSION MATERIAL	1.0E6	0.0	16000	16000	17000
9	DRI SPINE (MAN)	1.0E6	0.4E6	16000	16000	17000
10	DRI SPINE (DRI)	1.0E6	0.4E6	16000	16000	17000

KRASH INPUT DATA

CARDS 1000: NON-STANDARD MATERIAL PROPERTIES

DESCRIPTION: Defines non-standard material properties for beam elements in the KRASH model.

FORMAT AND EXAMPLE.

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

MC	☒	EE	GG	STENS	SCOMP	SHEAR	☒	☒	
11		10.3E06	3.9E06	35000.0	34000.0	17000.0			1000

FIELD	CONTENTS
MC	Material Code Number, MC = 11-20 (Right Justified Integer)
EE	Modulus Of Elasticity – Pounds Per Inch**2
GG	Modulus Of Rigidity – Pounds Per Inch**2
STENS	Tensile Yield Stress – Pounds Per Inch**2
SCUMP	Compressive Yield Stress – Pounds Per Inch**2
SHEAR	Shear Stress – Pounds Per Inch**2

REMARKS

(1) Optional data card(s).
(2) "NMTL" on card 0040 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) The yield stress properties are required when stress calculations are desired.
(5) The standard materials available in KRASH are listed in Table 2-2.
(6) Entries requiring scientific notation (X.XEXX) should be right justified.
(7) Format for this card is (I5, 5X, 5E10.0).

CARDS 1100: BEAM ELEMENT PINNED END CONDITIONS

DESCRIPTION: Defines the end points and the degrees-of-freedom for the beam elements with pinned end conditions in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

M	I	N	J	PYI	PZI	PYJ	PZJ	SF35	SF26	SF35J	SF26J	☒	
	2	6	0	0	1	0	1.0	1.5	1.2		1.0		1100

FIELD	CONTENTS
M	Massless Node Point Number At End "I"
I	Mass Point Number At End "I"
N	Massless Node Point Number At End "J"'
J	Mass Point Number At End "J"'
PYI	Pin Flag For Bending Moment About Beam Element Y-Axis At End "I"
PZI	Pin Flag For Bending Moment About Beam Element Z-Axis At End "I"
PYJ	Pin Flag For Bending Moment About Beam Element Y-Axis At End "J"
PZJ	Pin Flag For Bending Moment About Beam Element Z-Axis At End "J"
SF35	Beam Shape Factor At End "I" About Beam Y-Axis
SF26	Beam Shape Factor At End "I", About Beam Z-Axis
SF35J	Beam Shape Factor At End "J" About Beam Y-Axis
SF26J	Beam Shape Factor At End "J" About Beam Z-Axis

REMARKS:

(1) Optional data card(s).

(2) "NPIN" on card 0040 specifies the number of these cards for input.

(3) The pin flags are defined as follows:
0 = Fixed
1 = Pinned

(4) Blank entries are read as zero.

(5) All entries except SF26, SF35, SF26J and SF35J are right justified integers. SF26, SF35, SF26J and SF35J are E10.0 format.

(6) The beam element Y- and Z-axis directions depend on the beam element geometric orientation as shown in Figure 2-3.

(7) Bending moments about the beam element Y- and Z-axes correspond to bending moments in the beam element X-Z and X-Y planes, respectively, as outlined in Table 2-3.

(8) All entries requiring scientific notation (X.XEXX) should be right justified.

(9) Format for this card is (2 (I2, I3), 4I5, 4E10.0).

(10) Beam shape factors SF26 and SF35, SF26J, and SF35J can be obtained from Table 2-4. and Reference 14.

(11) SF26, and/or SF35 values are required for representation of plastic hinge at beam end I.

(12) SF26J and/or SF35J values are required for representation of plastic hinge at beam end J.

NOTE: The end fixity card is used:

(a) to pin one or both ends of a beam

If a beam end is to be pinned then the desired PY, PZ, PYJ and PZJ flags are used and the SF26, SF35, SF26J and SF35J values are input as zero. The program will treat these beams as not providing for moments at the appropriate end and direction.

(b) to define a beam that can develop a plastic hinge at one or both ends of the beam.

If a plastic hinge is represented the appropriate beam end direction (PY, PZ, PYJ, PZJ) must be flagged and a corresponding (SF35, SF26, SF35J, SF26J) must have a value. The program will treat such a beam as fixed until such time as the plastic moment is formed. Thereafter the beam moment in the noted direction is maintained (no longer changes). In order to use the plastic moment equations the user must have beam section properties Z1 or Z2 (card 0900) defined since KRASH computes the plastic moment as follows:

$$M_p = f\left(\frac{\sigma_y I}{y_{max}}\right)$$

where

f = shape factor (SF35, SF26, SF35J, SF26J)

σ_y = material yield stress (contained in the material code table), lb/in^2

I = area moment of inertia, either I_{yy} or I_{zz} , in^4

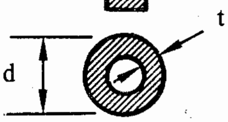
y_{max} = distance to neutral axis either Z1 or Z2 , in

The following table shows the relationship between directional moments and appropriate input terms for program KRASH.

TABLE 2-4. RELATIONSHIP FOR DIRECTIONAL MOMENTS AND INPUT TERMS IN KRASH

FORCE ALONG AXIS	MOMENT ABOUT AXIS	FORCE, MOMENT DESIGNATION	KRASH DIRECTION NUMBERS	APPROPRIATE INPUT REQUIREMENT					
				AREA MOMENT OF INERTIA (CARD 0900)	DISTANCE FROM N.A. TO ELEMENT EXTREME FIBER (CARD 0900)	SHAPE FACTOR		PIN CODING	
						"i" END	"j" END	"i" END	"j" END
z	y	F_z, M_θ	3, 5	IYY	Z1	SF35	SF35J	PY	PYJ
y	z	F_y, M_ψ	2, 6	IZZ	Z2	SF26	SF26J	PZ	PZJ

TABLE 2-5. SHAPE FACTORS FOR PLASTIC HINGE BEAMS (Reference 14)

SHAPE	SHAPE FACTOR, f (SF35, SF26, SF35J, SF26J) IN PROGRAM KRASH
	2.37
	2.0
	1.7
	1.5
	1.40 t/d = 10 1.27 t = 0
	1.15 Ranges 1.10 to 1.22

0 $f = Z/S$

$Z = 2 H_e$

$S = I/Y_{max}$

where:

I = Section area moment of inertia

Y_{max} = Distance from neutral axis to extreme fiber

H_e = Static moment of half the cross section with respect to the neutral axis

Z = Plastic modulus

S = Elastic section modulus

f = Shape factor

CARDS 1200: AXIALLY UNSYMETRIC BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines end points, type of load, and deadband for the beam elements with unsymetrical axial properties in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	IJUB	☒	DB	☒	☒	☒	☒	☒	
	2	1	5	−1		1.5						1200

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
IJUB	Flag For The Type Of Axial Loading In The Beam Elements IJUB = +1, Tension Only IJUB = -1, Compression Only
DB	Deadband for axial loading, inches

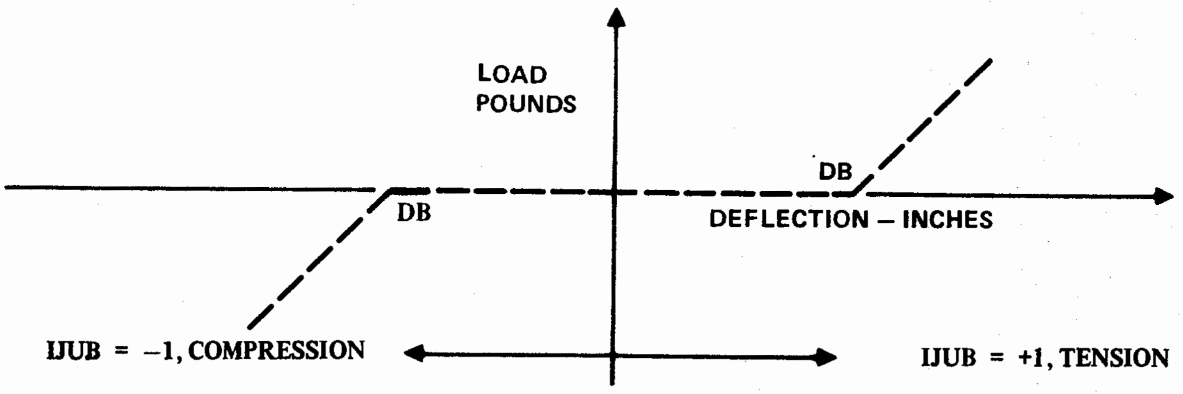
REMARKS:

(1) Optional data card(s).

(2) "NUB" on card 0040 specifies the number of these cards for input.

(3) Blank entries are read as zero.

(4) The general form of the load-deflection curve for the axially unsymetric beam element is as follows:



(5) This type of beam element may also incorporate nonlinear characteristics by specifying the nonlinear properties per the 1800-series cards.

(6) The axial load-deflection curves that can be obtained using this capability are described in Volume I, Section 1.3.5.3.5. (Reference 1)

(7) Format for this card is (2 (I2, I3), I5, 5X, E 10.0).

KRASH INPUT DATA

CARD 1290: SHOCK STRUT DATA

DESCRIPTION: Friction coefficient and number of metering pin tables.

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

ALPHAP	NMPTAB	☒	☒	☒	☒	☒	☒	
1.0	2							1290

FIELD	CONTENTS
ALPHAP	Constant For Use In Computing Shock Strut Friction Force
NMPTAB	Number of Separate Metering Pin Tables Input on Cards 1490/1500.

REMARKS:

(1) Optional data card.
(2) Required only if NOLEO ≠ 0 (card 0040)
(3) Only 1 card regardless of NOLEO value
(4) Blank entry read as zero
(5) Range of ALPHAP is between .1 to 2.0. The smaller the alphap used the closer the representation is to pure Coulomb friction. Generally a value of 1.0 is suitable.
(6) See Appendix A for the discussion on oleo friction forces for alphap selection.
(7) Format for this card is (E10.0, I10).

CARDS 1300: SHOCK STRUT DATA

DESCRIPTION: Air curve parameters

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	EOLEO	FAO	FAA	EXPOLE	YMAX			
	1		7	10.27	116.	5.	1.0	9.32			1300

FIELD	CONTENTS
M	Massless Node Point Number In End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
EOLEO	Effective Total Strut Cylinder Length, in.
FAO	Fully Extended Gear Preload, lb.
FAA	Ambient Air Preload, lb.
EXPOLE	Polytropic Exponent.
YMAX	Maximum Stroke, in.

REMARKS:

(1) Optional data cards.
(2) "NOLEO" on card 0040 specifies the number of these cards for input.
(3) All entries requiring scientific notation (X.XEXX) should be right justified.
(4) EXPOLE ranges from 1 (isothermal) to 1.4 (adiabatic). Adiabatic condition will usually prevail.
(5) See Appendix A for a description of the shock strut parameters and their usage.
(6) Format for this card is (2 (I2, I3), 5E10.0).

KRASH INPUT DATA

CARDS 1400: SHOCK STRUT DATA

DESCRIPTION: Damping constants, linear springs at extended and compressed ends of strut travel and coulomb friction.

FORMAT EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

M	I	N	J	BOLEO	BROLEO	XKEXT	XKCOMP	FCOUL	MPTAB	☒	
	1		7	0.24	0.48	10000.	10000.	5.5	1		1400

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
BOLEO	Strut Orifice Damping lb-sec^2/in^2
BROLEO	Strut Rebound Valve Damping lb-sec^2/in^2
XKEXT	Linear Spring At Extended End Of Strut Travel, lb/in.
XKCOMP	Linear Spring At Compressed End Of Strut Travel, lb/in.
FCOUL	Coulomb Or Constant Friction Force, lbs.
MPTAB	Metering Pin Table Number. If a Metering Pin Is Not Used, Input Zero. MPTAB Refers to Metering Pin Tables Input Sequentially On 1500-Series Cards.

REMARKS:

(1) Optional data cards.
(2) "NOLEO" on card 0040 specifies the number of these cards for input.
(3) All entries requiring scientific notation (X.XEXX) should be right justified.
(4) See Appendix A for a description of the shock strut parameters and their usage.
(5) If a metering pin table is used, BOLEO is ignored. If MPTAB is input as a negative integer, the subsequent table on cards 1500 is interpreted as total gear load versus stroke. This is used only for the inverse metering pin option, explained in Appendix A.
(6) No. of cards = NPTSMP value (card 1290)
(7) Format for this card is (2 (I2, I3), 5E10.0, I10).

CARD 1490: METERING PIN DATA

DESCRIPTION: Number of points in following metering pin table

FORMAT EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890		
NPTSMP		
15		**1490**

FIELD	CONTENTS
NPTSMP	Number of Cards in The Following Table of YOLEO Versus BOLEO (Maximum Allowable is 100)

REMARKS:

(1) Optional data card. Required only if MPTAB is nonzero on any of the 1400-Series cards.

(2) This card precedes each 1500-Series of metering pin table cards. For example, if there were 3 metering pin tables (NMPTAB = 3 on card 1290), the proper sequence would be

1490	1 card
1500-XX	NPTSMP$_1$ cards
1490	1 card
1500-XX	NPTSMP$_2$ cards
1490	1 card
1500-XX	NPTSMP$_3$ cards

(3) Format for this card is I10

CARDS 1500: METERING PIN DATA

DESCRIPTION: Table(s) of oleo piston compression versus damping constant.

FORMAT EXAMPLE

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890			
YOLEO	BOLEO		
7.	1.76E02		**1500**

FIELD	CONTENTS
YOLEO	Oleo Piston Compression, Inches, Measured From Fully Extended Position
BOLEO	Oleo Hydraulic Damping Constant, Pount-Sec ^{2}/in^2, at The Piston Position Defined by YOLEO

REMARKS

(1) Optional data card(s). NPTSMP on card 1490 defines the number of these cards to input. If NMPTAB = 0 on card 1290, then none of these cards are used.

(2) Format for this card is 2E10.0.

(3) If MPTAB on card 1400 is input as a negative integer, then BOLEO on the corresponding 1500-Series cards is interpreted as total gear load. This is referred to as the inverse metering pin option, which can be used to calculate BOLEO versus YOLEO if a known (or desired) load-deflection characteristic curve is input on this series of cards. This option is explained in Appendix A.

CARD 1600: BEAM ELEMENT DAMPING RATIO

DESCRIPTION: Defines an overall damping ratio for the beam elements in the KRASH model.

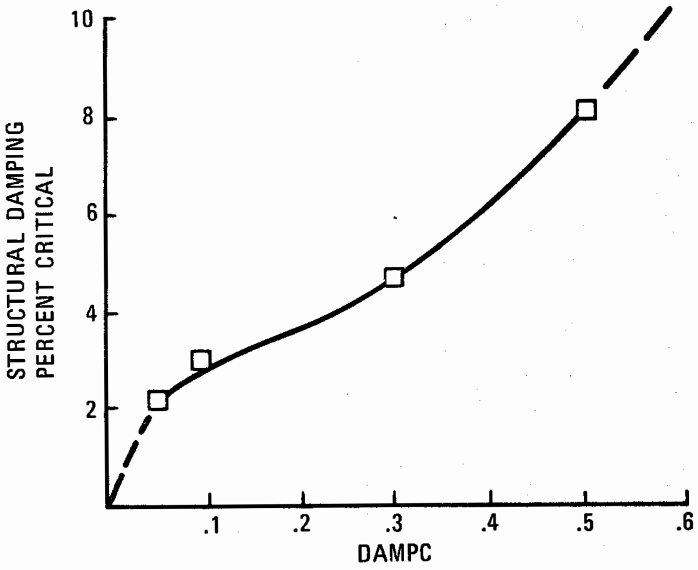
FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

DAMPC								
0.10								**1600**

FIELD	CONTENTS
DAMPC	Damping Ratio (Actual/Critical)

REMARKS:
(1) Required data card; however, it may be blank.
(2) Blank entry is read as zero damping for all beams.
(3) DAMPC values in KRASH are between .1 and .5. The sketch below shows the relationship between DAMPC values and percent of critical damping.
(4) Format for this card is E10.0



CARDS 1700: NON-STANDARD BEAM ELEMENT DAMPING RATIOS

DESCRIPTION: Defines the end points and damping ratio for each beam element in the KRASH model for which a non-standard damping ratio is required.

FORMAT AND EXAMPLE:

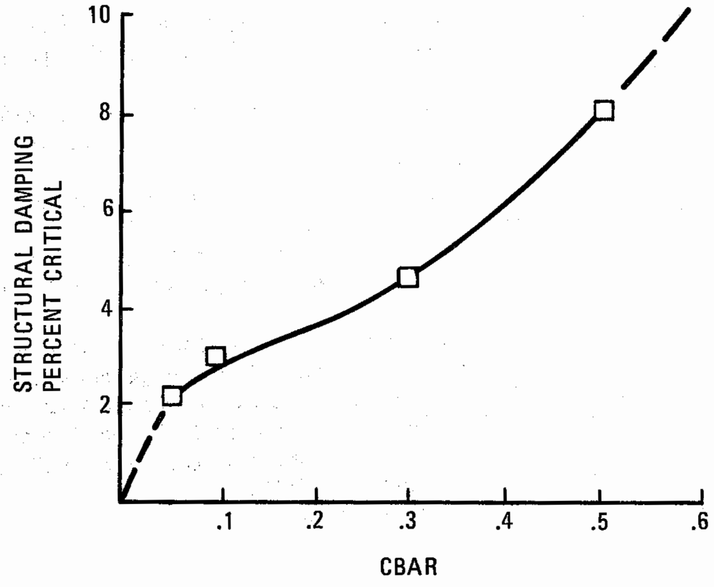
0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	CBAR	☒	☒	☒	☒	☒	☒	
	2	1	5	0.10							**1700**

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J"' (Right Justified Integer)
CBAR	Damping Ratio (Actual/Critical)

REMARKS:

(1) Optional data card(s).
(2) "ND" on card 0040 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) CBAR values in KRASH are between .1 and .5. The sketch below shows the relationship between CBAR values and percent critical damping.
(5) Format for this card is (2 (12, 13), E10.0).



CARDS 1800: NONLINEAR BEAM ELEMENT PARAMETERS

DESCRIPTION: Defines the end points, degree-of-freedom, KR table type, and linear deflection points for the nonlinear beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J	L	NP	LDP	LDP1	☒	☒	☒	☒	
	2	1	5	3	7	1.5	0.0					1800

FIELD	CONTENTS
M	Massless Node Point Number At End "1" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
L	Nonlinear Degree-Of-Freedom Where L = 1, 2, 3, 4, 5, 6 Corresponds To The Beam Element Coordinate System Directions X, Y, Z, ϕ, θ, ψ. Respectively (Right Justified Integer)
NP	Number Of Data Points Used In KR Table (Right Justified Integer)
LDP	Deflection At Which Nonlinear Behavior Begins – Inches
LDP1	Deflection At Which Nonlinear Behavior Ends And Linear Restiffening Begins – Inches except as noted in remark (8).

REMARKS:

(1) Optional data card(s).

(2) "NLB" on card 0040 specifies the number of these cards for input.

(3) Blank entries are read as zero.

(4) The nonlinear degrees-of-freedom are specified in the beam element coordinate systems shown in figure 2-3.

(5) For "NP" = 4-9 the corresponding standard KR tables are shown in figure 2.6. For "NP" $>$ 9 the user will input a nonstandard KR table with "NP" data points. For user input KR tables – $15 \geq NP \geq 10$.

(6) "LDP1" is used for the KR table "NP" = 9 and for "NP" = 4 (see remark 8).

(7) The theory on how the KR's are used to calculate internal beam loads is shown in Volume I, Section 1.3.5.3.4. (Reference 1).

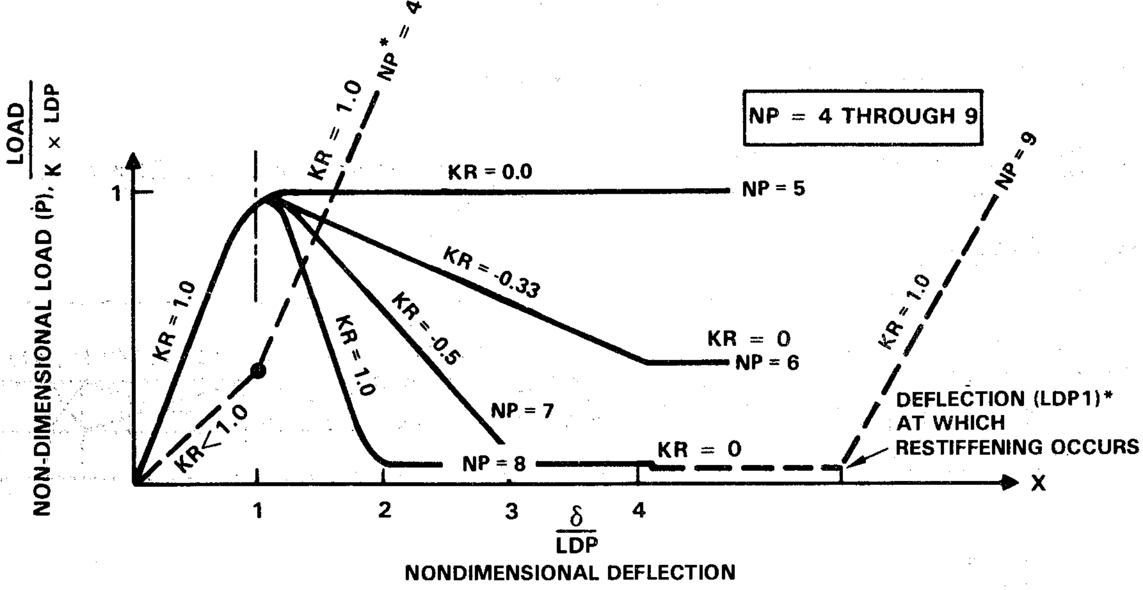
(8) For "NP" = 4 the LDP value represents the deflection value at which KR = 1. (LINEAR). The LDP1 value is used to represent the KR value ($<$ 1) for the range: $0 \leq$ deflection $\leq$ LDP. NP = 4 can be useful for modeling elements such as a seat cushion which is soft initially and stiffens during compression. Do not use with LDP1 $>$ 1.0.

(9) A KR value represents the slope associated with a change in beam load and deflection over an incremental time. Thus a KR = 0 (zero slope) indicates the incremental load is zero. For a KR = 1 the incremental load increases an amount equal to the beam element stiffness times the change in deflection. For a KR = -.5 the change in load is decreased by an amount equal to one-half the beam element stiffness times the change in deflection.

(10) Format for this card is (2 (I2, I3) 2I5, 2E10.0).

- **LINEAR STIFFNESS = K (INPUT DATA)**
- **DEFLECTION AT FAILURE = LDP (INPUT DATA)**
- **LOAD AT FAILURE = K × LDP**
- **BEAM DEFLECTION = δ**

***SEE REMARKS (6) AND (8) ON PAGE 2-60**



(A) RELATIONSHIP BETWEEN KR-DEFLECTION AND LOAD-DEFLECTION DATA FOR KRASH STANDARD TABLES

NUMBER OF POINTS	NP VALUE											
	4		5		6		7		8		9	
	KR	δ	KR	δ	KR	δ	KR	δ	KR	δ	KR	δ
1	< 1.	0	1.	0	1.	0	1.	0	1.	0	1	0
2	< 1.	LDP	1.	LDP	1.	LDP	1.	LDP	1.	LDP	1	LDP
3	1.	1.001x LDP	0	1.001x LDP	-.25	1.001x LDP	-.5	1.001x LDP	-1.	1.001x LDP	-1.	1.001x LDP
4	1.	10x LDP	0	10x LDP	-.25	4x LDP	-.5	3x LDP	-1.	2x LDP	-1.	2.0x LDP
5	—	—	0	1000x LDP	0	4.001x LDP	0	3.001x LDP	0	2.001x LDP	0	2.001x LDP
6	—	—	—	—	0	10x LDP	0	10x LDP	0	10x LDP	0	LDP1
7	—	—	—	—	—	—	0	10.00 x LDP	0	15x LDP	1.	1.001x LDP1
8	—	—	—	—	—	—	—	—	0	1000x LDP	1.	20x LDP1
9	—	—	—	—	—	—	—	—	—	—	1.	1000x LDP1

(B) STANDARD STIFFNESS REDUCTION (KR) VS DEFLECTION (δ) TABLES CODED IN KRASH

FIGURE 2-6. STANDARD NONLINEAR BEAM KR-DEFLECTION AND LOAD-DEFLECTION DATA

CARDS 1900: NON-STANDARD KR TABLE DATA POINTS

DESCRIPTION: Defines non-standard KR tables for the nonlinear beam elements in the KRASH model which cannot be described with the standard KR tables.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

XKR	KR	☒	☒	☒	☒	☒	☒	
1.0	−1.0							1900

FIELD	CONTENTS
XKR	Deflection – Inches
KR	Stiffness Reduction Factor at XKR

REMARKS:

(1) Optional data cards.
(2) For each use of "NP" > 9 on the 1200-series cards, "NP" of these cards are required input.
(3) Blank entries are read as zero.
(4) Within each set of "NP" data cards, deflections must be in ascending order.
(5) Each set of "NP" data cards must be ordered to correspond with the 1800 – series cards where "NP" > 9 is used.
(6) Format for this card is 2E10.0.

CARD 2000: CONTROL VOLUME MASS PENETRATION PARAMETERS

DESCRIPTION: Defines a control volume around a selected mass point in the KRASH model which is monitored for penetration by another mass point during the analysis.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

XN	XP	YN	YP	ZN	ZP	☒	☒	
10.0	10.0	3.0	4.0	10.5	2.9			2000

FIELD	CONTENTS
XN	Distance From Mass Point To Aft Side Of Control Volume
XP	Distance From Mass Point To Forward Side Of Control Volume
YN	Distance From Mass Point To Left Side Of Control Volume
YP	Distance From Mass Point To Right Side Of Control Volume
ZN	Distance From Mass Point To Top Side Of Control Volume
ZP	Distance From Mass Point To Bottom Side Of Control Volume

REMARKS:

(1) Optional data card.
(2) 'MVP" on card 0040 specifies the mass point number for which this data card applies.
(3) Only one mass point may have a control volume.
(4) Blank entries are read as zero.
(5) All distances are positive and units are inches.
(6) For a RUNMOD = 2 the MVP mass should be selected from a mass point located on the airplane centerline. This restriction doesn't apply to RUNMOD = 0 or 1.
(7) Any of the model mass points may penetrate the designated control volume of the model.
(8) The mass penetration calculations are described in Volume I, Section 1.3.10.
(9) Format for this card is 6E10.0.

KRASH INPUT DATA

CARD 2100: DRI ELEMENT SPECIFICATION

DESCRIPTION: Defines the end mass points of the DRI beam elements in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I1	J1	I2	J2	I3	J3	I4	J4	I5	J5	I6	J6	I7	J7	☒	
3	10														2100

FIELD	CONTENTS
II	Mass Point Number At End "I"
JI	Mass Point Number At End "J"

REMARKS:

(1) Optional data card(s).
(2) "NDRI" on card 0040 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Blank entries are read as zero.
(5) Up to seven DRI beam elements can be specified on each card. (Normally an analysis requires from 1 to 4 DRI elements).
(6) DRI beam element section properties can be defined on the 0900-series cards or if a MTL code of 10 is used the program will automatically compute the DRI properties.
(7) Beams that connect massless node points cannot be used as DRI elements, only direct mass to mass connection is allowed.
(8) The usage of DRI elements is described in Volume I, Section 1.3.12.
(9) Format for this card is 14I5.

CARD 2200: OCCUPIABLE VOLUME CHANGE PARAMETERS

DESCRIPTION: Defines occupiable volumes in the KRASH model for volume change calculations by specifying the eight corner mass points.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

I1	I2	I3	I4	I5	I6	I7	I8	☒	☒	☒	☒	
3	7	12	13	21	23	31	35					2200

FIELD	CONTENTS
I1	Mass Point Number At Forward End, Upper Left-Hand Corner
I2	Mass Point Number At Forward End, Upper Right-Hand Corner
I3	Mass Point Number At Aft End, Upper Left-Hand Corner
I4	Mass Point Number At Aft End, Upper Right-Hand Corner
I5	Mass Point Number At Forward End, Lower Left-Hand Corner
I6	Mass Point Number At Forward End, Lower Right-Hand Corner
I7	Mass Point Number At Aft End, Lower Left-Hand Corner
I8	Mass Point Number At Aft End, Lower Right-Hand Corner

REMARKS:

(1) Optional data card(s).
(2) "NVCH" on card 0004 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Blank entries are not allowed.
(5) The volume change calculations are explained in Volume I, Section 1.3.11 (Figure 1-16).
(6) For a symmetrical full model (RUNMOD = 2 type) when only half the data is input the user inputs mass point locations 1, 3, 5, 7 (I1, I3, I5, I7). The opposite side mass point locations 2, 4, 6, 8 (I2, I4, I6, I8) are input as zero (blank). KRASH automatically computes the opposite side masses. See Volume I, Figure 1-16 for mass point designations.
(7) Format for this card is 8I5.

CARDS 2300: NON-STANDARD MAXIMUM BEAM ELEMENT POSITIVE DEFLECTIONS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum positive deflections and rotations for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="12">0 1 2 3 4 5 6 7 8</td></tr>
<tr><td colspan="12">12345678901234567890123456789012345678901234567890123456789012345678901234567890</td></tr>
<tr><td>M</td><td>I</td><td>N</td><td>J</td><td>VMAX1</td><td>VMAX2</td><td>VMAX3</td><td>VMAX4</td><td>VMAX5</td><td>VMAX6</td><td>☒</td><td></td></tr>
<tr><td></td><td>2</td><td>1</td><td>6</td><td>10.0</td><td>15.2</td><td>100.0</td><td>100.0</td><td>0.2</td><td></td><td></td><td>2300</td></tr>
</table>

FIELD	CONTENTS
M	Massless Node Point Number At End "1" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
VMAX1	Maximum Deflection In Beam Element X-Direction – Inches
VMAX2	Maximum Deflection In Beam Element Y-Direction – Inches
VMAX3	Maximum Deflection In Beam Element Z-Direction – Inches
VMAX4	Maximum Rotation About Beam Element X-Axis – Radians
VMAX5	Maximum Rotation About Beam Element Y-Axis – Radians
VMAX6	Maximum Rotation About Beam Element Z-Axis – Radians

REMARKS:

(1) Optional data card(s).

(2) "NVBM" on card 0050 specifies the number of these cards for input.

(3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.

(4) The beam element coordinate systems are shown in Figure 2-5.

(5) All values are input as positive numbers.

(6) Format for this card is (2 (I2, I3), 6E10.0).

CARDS 2400:

NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE DEFLECTIONS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum negative deflections and rotations for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890											
M	I	N	J	VMAXN1	VMAXN2	VMAXN3	VMAXN4	VMAXN5	VMAXN6		
	2	1	6	10.0	15.2	100.0	100.0	0.2	100.0		2400

FIELD	CONTENTS
M	Massless Node Point Number At End "I" (Right Justified Integer)
I	Mass Point Number At End "I" (Right Justified Integer)
N	Massless Node Point Number At End "J" (Right Justified Integer)
J	Mass Point Number At End "J" (Right Justified Integer)
VMAXN1	Maximum Deflection In Beam Element X-Direction – Inches
VMAXN2	Maximum Deflection In Beam Element Y-Direction – Inches
VMAXN3	Maximum Deflection In Beam Element Z-Direction – Inches
VMAXN4	Maximum Rotation About Beam Element X-Axis – Radians
VMAXN5	Maximum Rotation About Beam Element Y-Axis – Radians
VMAXN6	Maximum Rotation About Beam Element Z-Axis – Radians

REMARKS:

(1) Optional data card(s).

(2) "NVBMN" on card 0050 specifies the number of these cards for input.

(3) The standard or default values for maximum deflections and rotations are 100 inches and 100 radians, respectively. The deflections and rotations refer to relative motions of the j end of the beam minus the i end of the beam.

(4) The beam element coordinate systems are shown in Figure 2-5.

(5) All values are input as positive numbers.

(6) Format for this card is (2 (I2, I3), 6E10.0).

CARDS 2500: NONSTANDARD MAXIMUM BEAM ELEMENT POSITIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

M	I	N	J	FMAX1	FMAX2	FMAX3	FMAX4	FMAX5	FMAX6	☒	
	3		7	10.0E10	1000.0	10.0E10	10.0E10	10.0E6	10.0E10		2500

FIELD	CONTENTS
M	Massless Node Point Number at End “I” (Right Justified Integer)
1	Mass Point Number at End “1” (Right Justified Integer)
N	Massless Node Point Number at End “J” (Right Justified Integer)
J	Mass point Number at End “J” (Right Justified Integer)
FMAX1	Maximum Axial Force in Beam Element X-Direction - Pounds
FMAX2	Maximum Shear Force in Beam Element Y-Direction - pounds
FMAX3	Maximum Shear Force in Beam Element Z-Direction - Pounds
FMAX4	Maximum Torque About Beam Element X-Axis - Inch * Pounds
FMAX5	Maximum Bending Moment About Beam Element Y-Axis - Inch * Pounds
FMAX 6	Maximum Bending Moment About Beam Element Z-Axis - Inch * Pounds

REMARKS:

(1) Optional data card(s).
(2) “NFBM” on card 0050 specifies the number of these cards for input.
(3) The standard of default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Blank entries are read as zero.
(6) The beam element coordinate systems are shown in Figure 2-5.
(7) All values are input as positive numbers.
(8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
(9) Format for this card is (2(I2, I3), 6E10.0).

CARDS 2600: NON-STANDARD MAXIMUM BEAM ELEMENT NEGATIVE LOADS FOR RUPTURE

DESCRIPTION: Defines the end points and the maximum forces and moments for rupture of beam elements in the KRASH model.

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="12">0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890</td></tr>
<tr><td>M</td><td>I</td><td>N</td><td>J</td><td>FMAXN1</td><td>FMAXN2</td><td>FMAXN3</td><td>FMAXN4</td><td>FMAXN5</td><td>FMAXN6</td><td>☒</td><td></td></tr>
<tr><td></td><td>3</td><td></td><td>7</td><td>10.0E10</td><td>1000.0</td><td>10.0E10</td><td>10.0E10</td><td>10.0E6</td><td>10.0E10</td><td></td><td>2600</td></tr>
</table>

FIELD	CONTENTS
M	Massless Node Point Number at End 'I' (Right Justified Integer)
I	Mass Point Number at End 'I' (Right Justified Integer)
N	Massless Node Point Number at End 'J' (Right Justified Integer)
J	Mass Point Number at End 'J' (Right Justified Integer)
FMAXN1	Maximum Axial Force In Beam Element X-Direction – Pounds
FMAXN2	Maximum Shear Force In Beam Element Y-Direction – Pounds
FMAXN3	Maximum Shear Force In Beam Element Z-Direction – Pounds
FMAXN4	Maximum Torque About Beam Element X-Axis – Inch * Pounds
FMAXN5	Maximum Bending Moment About Beam Element Y-Axis – Inch * Pounds
FMAXN6	Maximum Bending Moment About Beam Element Z-Axis – Inch * Pounds

REMARKS:

(1) Optional data card(s).
(2) 'NFBMN' on card 0050 specifies the number of these cards for input.
(3) The standard or default values for maximum rupture forces and moments are 1.E10 pounds and inch-pounds, respectively.
(4) Entries requiring scientific notation (X.XEXX) should be right justified.
(5) Blank entries are read as zero.
(6) The beam element coordinate systems are shown in Figure 2-5.
(7) All values are input as positive numbers.
(8) The input values are compared to the time-varying beam loads at the j end of the beam to determine if beam rupture occurs.
(9) Format for this card is (2(I2, I3), 6E10.0).

CARDS 2700: LOAD INTERACTION CURVE SIGN CONVENTION DATA

DESCRIPTION: Defines the sign conventions to be used for load-interaction data output.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

ISCV1	ISCV2	ISCV3	ISCV4	ISCV5	ISCV6		
3	-2	5	6	-4	1		2700

FIELD: CONTENTS

ISCV1-ISCV6 CALAC (Lockheed-California Co.) sign convention load number to be used for the corresponding user defined loads. The above example results in the following correspondence between the user-defined loads and the CALAC sign convention loads:

User Loads	1	2	3	4	5	6	are made up of
CALAC Loads	3	-2	5	6	-4	1	

REMARKS:

(1) Optional data card(s).
(2) NSCV on card 0060 defines the number of these cards for input.
(3) Any nonzero ISCN on the 2800-series cards requires a corresponding sign convention definition card in the 2700 series.
(4) Section 3.1 describes the load-interaction data and the significance of the user-defined sign conventions.
(5) The format for this card is 6I5

CARDS 2800: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the beams to be analyzed for load-interaction curves, the two interacting load directions, sign conventions to be applied, exact location along the beams and rupture ratio.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

IJ	K	L	NLIL	ISCN	NSMI	FSLIC	BLLIC	WLLIC	RUPRAT		
7	3	5	3	1	10	1160.			1.4		**2800**

FIELD	CONTENTS
IJ	Beam number, the internal loads from which are to be analyzed on load-interaction diagrams.
K,L	Load directions for the x and y axes of load-interaction curve. In the above example, 3,5 means use Fz and My, in the user-defined sign convention.
NLIL	Number of sloping load-interaction lines, the data for which is defined on the 3000-series cards. The maximum allowed per load-interaction diagram is 20, including those lines generated as mirror images.
ISCN	User-defined sign convention number to be applied to the beam internal loads before selecting the K,L loads for this load interaction diagram. If ISCN = 0, then the CALAC internal load sign convention, defined in Section 4.15 reference 1, is used.
NSMI	Number of masses involved if shear and moment summation of a particular station is required.
FSLIC, BLLIC, WLLIC	Defines the location on the airplane for this load-interaction curve. Input only one of these nonzero. For fore-aft beams, use FSLIC. For lateral beams use BLLIC. For vertical beams, use WLLIC. The location input must be physically within the end points of beam IJ. In the example shown, a load-interaction curve is defined for beam number 7, which is a fore-aft beam, at FS 1160.
RUPRAT	Beam IJ will rupture when the maximum load ratio for this interaction curve exceeds RUPRAT. If the input data on cards 2900 and 3000 define a strength envelope which at any point would cause complete failure of the structure represented by beam IJ, then RUPRAT = 1.0 would be appropriate. A very large value (RUPRAT = 1000) will guarantee that beam rupture is not triggered by the load-interaction curve calculations.

REMARKS:

(1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.

(2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.

(3) Section 3.1 describes the load-interaction calculations and data.

(4) Format for this card is (6I5, 4E10.0).

CARDS 2900: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the maximum load levels along the positive and negative x and y load axes.

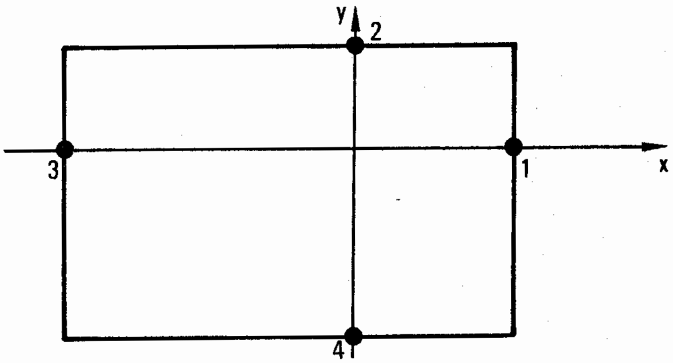
FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

	FMXLIC1	FMXLIC2	FMXLIC3	FMXLIC4		
	254000.	74.0E06	-254000.	-74.0E06		**2900**

FIELD	CONTENTS
FMXLIC1 FMXLIC2 FMXLIC3 FMXLIC4	Maximum load levels along the positive and negative x and y load axes. Sequence is as follows: 1 = + x axis 2 = + y 3 = - x 4 = - y

These lines form a rectangular load-interaction strength envelope that looks like:



REMARKS:

(1) Optional data card. NLIC on card 0060 defines the number of these cards to be input.

(2) For each load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.

(3) Section 3.1 describes the load-interaction calculations and data.

(4) Format for this card is (30X, 4E10.0).

(5) A zero or blank input for any of these 4 values will invoke a default value of 1.E20 pounds or inch-pounds.

(6) FMXLIC3 and FMXLIC4 are input as negative numbers.

CARDS 3000: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines the intercepts for sloping load interaction lines and mirror image flags for generating these lines in other load quadrants.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8 12345678901234567890123456789012345678901234567890123456789012345678901234567890					
MXY1	MXY2	FLIC1	FLIC2		
1	1	1500.	30.E06		**3000**

FIELD CONTENTS

MXY1
MXY2

Mirror image flags defining additional load-interaction lines that are generated internally in KRASH, based on the line defined by FLIC1 and FLIC2. The following combinations are possible:

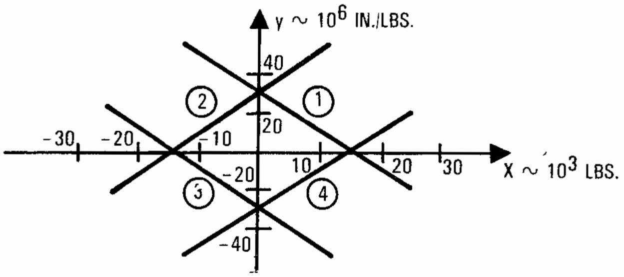
MXY1	MXY2	RESULT	Total No. of L.I. Lines
0	0	No mirror images generated	1
0	1	Mirror about y axis only	2
1	0	Mirror about x axis only	2
1	1	Mirror about x and y axes	4

FLIC1
FLIC2

Intercept of sloping load-interaction line with x (FLIC1) and y (FLIC2) axes. These two numbers define a single load interaction line, while MXY1 and MXY2 can be used to generate additional lines which are symmetrical about the x, y or both axes.

REMARKS:

(1) Optional data. NLIC on Card 2800 defines the number of these cards to be input
(2) For ecah load-interaction curve, cards 2800, 2900 and 3000 are input in sequence, before the next 2800-3000 series. In other words, the 2800-3000 card sequence is repeated NLIC times.
(3) Section 3.1 describes the load-interaction calculations and data.
(4) Format for this card is (2I5, 2E10.0).
(5) For each load-interaction curve, a maximum of 20 load-interaction lines are allowed. The limit of 20 includes any lines generated by KRASH through nonzero inputs of MXY1 and MXY2.
(6) The example data will generate the following load-interaction strength envelope:



Load-interaction line 1 is generated by the user-input FLIC1 and FLIC2. Lines 2-4 are generated by KRASH because MXY1 = MXY2 = 1.

CARDS 3010: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines water line at forward and aft ends of segment for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

0 1234567890	1 1234567890	2 3 4 5 6 7 1234567890123456789012345678901234567890123456789012345678901234567890	8 1234567890
WLSMF	WLSMA		
215.7	206.4		**3010**

FIELD	CONTENTS
WLSMF	Water line at beam forward end.
WLSMA	Water line at beam aft end.

REMARKS:
(1) Optional data card. Use only if NSMI on card 2800 is > 0.
(2) Beam number (IJ) is defined.
(3) Format for this card is (2E10.0).

CARDS 3020: LOAD INTERACTION CURVE DATA

DESCRIPTION: Defines masses located at station for which shear and moment loads are to be summed.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

IJSM1	IJSM2	IJSM3	IJSM4	IJSM5	IJSM6	IJSM7	IJSM8	IJSM9	IJSM 10	IJSM 11	IJSM 12	IJSM 13	IJSM 14		
33	41	49	57	65	84	104	105	118	119						**3020**

FIELD	CONTENTS
IJSM1 thru IJSM14	Mass Point Number (Right Justified Integer)

REMARKS:

(1) Optional data card. Use only if NSMI on card 2800 is > 0.
(2) Masses designed. IJSM1 thru IJSM14 must all be at same FS or BL station.
(3) 14 masses per card. Use NSMI/14 cards.
(4) Format for this card is (14I5).

CARDS 3100: MISCELLANEOUS MASS POINT PARAMETERS

DESCRIPTION: Defines any nonzero aerodynamic lift forces, angular moments of rotating masses, and mass cross products of inertia for mass points in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I	LC	HEX	HEY	HEZ	XYI	YZI	XZI	NHSY	
7	0.0	100.0	0.0	0.0	1.3	−3.3	0.0	0	3100

FIELD	CONTENTS
I	Mass Point Number (Right Justified Integer)
LC	Lift Coefficient For Aerodynamic Force, Positive Up
HEX	Angular Momentum of Rotating Masses About Mass Point X-Axis – Inch * Pound * Second
HEY	Angular Momentum of Rotating Masses About Mass Point Y-Axis – Inch * Pound * Second
HEZ	Angular Momentum of Rotating Masses About Mass Point Z-Axis – Inch * Pound * Second
XYI	Mass Cross Product of Inertia in Mass Point X-Y Plane – Inch * Pound * Second **2
YZI	Mass Cross Product of Inertia in Mass Point Y-Z Plane – Inch * Pound * Second **2
XZI	Mass Cross Product of Inertia in Mass Point X-Y Plane – Inch * Pound * Second **2
NHSY	Symmetry flag which defines the signs for HEX, HEY, HEZ for masses on the right side of the airplane, generated by subroutine GENMOD, if RUNMOD on card 110 is 2.

REMARKS:

(1) Optional data card(s).
(2) 'NHI' on card 0050 specifies the number of these cards for input.
(3) Blank entries are read as zero.
(4) The airplane weight is multiplied by the lift coefficient to generate an aerodynamic lift force on the mass point. This lift acts upward in ground axes.
(5) Format for this card is (I2, E8.0, 6E10.0, I2)
(6) NHSY = 0 corresponds to a symmetrical model (counter-rotating engines), so that

HEX-RIGHT = - HEX LEFT
HEY-RIGHT = + HEY LEFT
HEZ-RIGHT = - HEZ LEFT

NHSY = 1 corresponds to an anti-symmetrical model (engines rotate in same direction), so that

HEX-RIGHT = + HEX LEFT
HEY-RIGHT = - HEY LEFT
HEZ-RIGHT = + HEZ LEFT

CARD 3200: MASS POINT EULER ANGLES

DESCRIPTION: Defines for any mass point in the KRASH model three Euler angles to arbitrarily rotate the mass point or body coordinate system relative to the airplane coordinate system.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

I	☒	PHIDP	THEDP	PSIDP	☒	☒	☒	☒	
3		0.157	0.0	0.0					3200

FIELD	CONTENTS
I	Mass Point Number (Right Justified Integer)
PHIDP	Roll Euler Angle about Airplane X-Axis - Radians
THEDP	Pitch Euler Angle about Airplane Y-Axis - Radians
PSIDP	Yaw Euler Angle about Airplane Z-Axis - Radians

REMARKS:

(1) Optional data card(s).
(2) "NPH" on card 0050 specifies the number of these cards for input.
(3) Euler angles are order-dependent rotations. The order is PSIDP, THEDP, PHIDP.
(4) Blank entries are read as zero.
(5) These angles relate the mass-fixed axes to the airplane axes. Normally these axes coincide and therefore the angles are zero. If mass inertia were available in an inclined axis system the user might want to utilize this option. Another reason for inclining mass axes away from the airplane axes is to enable the user to orient an external spring in a direction that doesn't coincide with any of the airplane axes (external springs must point along one of the mass fixed axes).
(6) Roll angle positive when mass axes are "right-wing-down" relative to cg axes.
Pitch angle positive when mass axes are "nose-up" relative to cg axes.
Yaw angle positive when mass axes are "nose-right" relative to cg axes.
(7) Format for this card (I5, 5X, 3E10,0).

CARDS 3300: MASS POINT AERODYNAMIC COEFFICIENTS

DESCRIPTION: Defines for any mass point 6 aerodynamic load coefficients to be used to calculate aerodynamic loads.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I	☒	CXAIR	CYAIR	CZAIR	CLAIR	CMAIR	CNAIR		
13		-137.	0.	-1500.	3500.	5200.	7100.		3300

FIELD	CONTENTS
I	Mass point number
CXAIR	Aerodynamic drag coefficient, in^2
CYAIR	Aerodynamic side force coefficient, in^2
CZAIR	Aerodynamic lift coefficient, in^2
CLAIR	Aerodynamic rolling moment coefficient, in^3
CMAIR	Aerodynamic pitching moment coefficient, in^3
CNAIR	Aerodynamic yawing moment coefficient, in^3

REMARKS:

(1) Optional data card(s).
(2) NAERO on card 0050 specifies the number of these cards for input.
(3) The input aerodynamic coefficients are defined as follows:

CXAIR = S * CX alpha
CYAIR = S * CY beta
CZAIR = S * CZ alpha
CLAIR = S * b * CL beta
CMAIR = S * $\bar{c}$ * CM alpha
CNAIR = S * b * CN beta

where

S = Reference area, in^2
b = Reference span, in
$\bar{c}$ = Reference mean aerodynamic chord, in.
alpha = Angle of attack, rad. Positive when mass is nose up relative to its velocity vector.
beta = Sideslip angle, rad. Positive when mass is nose left relative to its velocity vector.
CXalpha = Slope of aerodynamic drag (positive forward) versus alpha, 1/rad
CYbeta = Slope of aerodynamic side force (positive right) versus beta, 1/rad
CZalpha = Slope of aerodynamic vertical force (positive down) versus alpha, 1/rad

<u>REMARKS:</u>
(Continued)

CLbeta = Slope of aerodynamic roll moment (positive right wing down) versus beta, 1/rad

CMalpha = Slope of aerodynamic pitch moment (positive nose up) versus alpha, 1/rad

CNbeta = Slope of aerodynamic yaw moment (positive nose right) versus beta, 1/rad

(4) All data refer to the local mass defined by I, not to the entire airplane.

(5) Aerodynamic loads at zero ALPHA are not included in the calculations. If necessary, these can be included as external forces/moments in the 3300 series cards.

(6) Aerodynamic loads using these coefficients are not included in the balanced initial conditions coding.

(7) The format for this card is (I5,5X,6E10.0).

CARDS 3400: MASS POINT TIME HISTORY ACCELERATION PARAMETERS

DESCRIPTION: Defines the mass point number, degree-of-freedom, and number of data points to specify an acceleration or load time history for any mass point in the KRASH model.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I	L	NP	NCODE	☒	☒	☒	☒	☒	☒	
3	2	10	1							3400

FIELD	CONTENTS
I	Mass Point Number.
L	Degree-of-Freedom where L = 1, 2, 3, 4, 5, 6 corresponds to X, Y, Z, θX, θY, θZ in the Mass Point Coordinate System
NP	Number of Data Points in the Table that specifies the Acceleration or Load Time History
NCODE	Flag defining whether the input table is of mass point acceleration or applied load.

REMARKS:

(1) Optional data card(s).
(2) "NACC" on card 0040 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) Each use of this card requires that "NP" number of the 3500-series cards be used.
(5) The masses must be input in sequence starting with the lower numbered masses.
(6) Format for this card is 4I5.
(7) NCODE = 0 for acceleration input table
NCODE = 1 for force/moment input table
(8) It is permissible to input forces for some masses and accelerations for other masses. If both types are input for the same mass, the accelerations will predominate.

CARDS 3500: MASS POINT ACCELERATION OR LOAD TIME HISTORY DATA TABLE

DESCRIPTION: Defines a table of time and acceleration or load data points for each mass point specified on the 3400-series cards.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

T	**ACCEL**	☒	☒	☒	☒	☒	☒	
0.01	-0.6							**3500**

FIELD	CONTENTS
T	Time - Seconds
Accel	Acceleration G's or Radians per Second **2 or Loads Pounds or Inch-Pounds

REMARKS:

(1) Optional data cards.
(2) For each of the "NACC" number of 3400-series cards, "NP" number of these cards are required.
(3) Within each set of data, the "NP" cards must be arranged in ascending order of time.
(4) Each set of data must be ordered to correspond with the 3400 series cards.
(5) Blank entries are read as zero.
(6) A maximum of 5000 acceleration times are allowed. For example, if accelerations are applied to 50 masses, the time history of each location can not exceed a curve consisting of 100 points.
(7) The values of acceleration or load are in mass axes, with translational accelerations in g's and rotational accelerations in rad/sec^2. Loads are in pounds or inch-pounds. (See Equation 1-117 Volume I).
(8) Format for this card is 2E10.0.

KRASH INPUT DATA

CARDS 3600: DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX

DESCRIPTION: Defines the end points and 6x6 stiffness matrix terms for any beam element in the KRASH model.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	N	J								
	2	1	7								2400

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K11	K12	K13	K14	K15	K16			
3500.0	0.0	0.0	0.0	0.0	0.0			2401

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K21	K22	K23	K24	K25	K26			
0.0	1.7E07	0.0	0.0	0.0	–2.2E05			2402

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K31	K32	K33	K34	K35	K36			
0.0	0.0	1.7E07	0.0	0.3E05	0.0			2403

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K41	K42	K43	K44	K45	K46			
0.0	0.0	0.0	15200.0	0.0	0.0			2404

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K51	K52	K53	K54	K55	K56			
0.0	0.0	0.3E06	0.0	3.5E09	0.0			2405

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

K61	K62	K63	K64	K65	K66			
0.0	–2.2E05	0.0	0.0	0.0	3.5E09			2406

CARDS 3600: DIRECT INPUT OF BEAM ELEMENT 6X6 STIFFNESS MATRIX (Continued)

FIELD	CONTENTS
M	Massless Node Point Number at end "I" (Right Justified Integer)
I	Mass Point Number at end "I" (Right Justified Integer)
N	Massless Node Point Number at end "J" (Right Justified Integer)
J	Mass Point Number at end "J" (Right Justified Integer)
KIJ	Stiffness Matrix Terms - Pounds per Inch or Inch * Pounds per Radian

REMARKS:

(1) Optional data cards.
(2) "NKM" on card 0050 specifies the number of these card sets for input.
(3) Blank entries are read as zero.
(4) The beam element must be included on the 0900-series cards.
(5) The stiffness data on these cards will override any values calculated with the beam element section properties on the 0900-series cards.
(6) The input 6x6 stiffness matrix corresponds to the lower right-hand quadrant of a full 12x12 beam element stiffness matrix, shown as Equation (1-23) in Volume I.
(7) Entries requiring scientific notation (X.XEXX) should be right justified.
(8) Format for the beam identification card is 2(I2, I3).
(9) Format for the stiffness matrix data cards is 6E10.0.

CARDS 3700-3800: MASS POINT POSITION (STRUCTURE DEFORMATION) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the planar view, scale factors, and mass point numbers for each mass point position (structure deformation) printer plot.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

NTPL	NMPTS	ISCALE	☒	XSCALE	YSCALE	☒	☒	☒	☒	
1	10	3		10.0	10.0					3700

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M1	M2	M3	M4	M5	M6	M7	M8	M9	M10	M11	M12	M13	M14	☒	
1	2	5	6	7	11	13	14	21	27						3800

FIELD	CONTENTS
NTPL	Flag to select Planar View where NTPL = 1, 2, 3 corresponds to top, side, and frontal views, respectively (Right Justified Integer)
NMPTS	Number of Mass Points (Right Justified Integer - Maximum allowed is 50)
ISCALE	Flag to Select Scaling Option as follows (Right Justified Integer):

ISCALE	TYPE OF SCALING
0	Automatic scaling where horizontal and vertical plot axes scales are selected independently based on the corresponding largest mass point displacement components.
1	Automatic scaling where horizontal and vertical plot axes scales are set equal based on largest mass point displacement component.
3	User defined scaling

XSCALE	Horizontal Scale Factor required if "ISCALE" = 3
YSCALE	Vertical Scale Factor required if "ISCALE" = 3
M1	Mass Point Number (Right Justified Integer)

REMARKS:

(1) Optional data cards.
(2) "NPLT" on card 0140 specifies the number of these card sets for input.
(3) "NTPL," "NMPTS," and "MI" must be nonzero.
(4) Blank entries are read as zero.
(5) Scale factor units are inches of mass point displacement per inch of paper.
(6) Entries requiring scientific notation (X,XEXX) should be right justified.
(7) Recommend ISCALE = 3 if user plans to compare or overlay plots at different time periods.
(8) Format for card 3700 type is (3I5,5X,2E10.0).
(9) Format for card 3800 type is 14I5.

CARDS 3900: MASS POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number and flags to specify which mass point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

I	MP1	MP2	MP3	MP4	MP5	MP6	MP7	MP8	MP9				
3	0	1	0	1	0	0	1	0	1				3900

FIELD	CONTENTS
I	Mass Point Number
MP1	Flag for Linear Displacements (X, Y, Z - Inches) in the Ground Coordinate System
MP2	Flag for Euler Angles (PHI, THETA, PSI - Radians) in the Airplane Coordinate System
MP3	Flag for Linear Velocities (X, Y, Z - Inches per Second) in the Ground Coordinate System
MP4	Flag for Linear Velocities (U, V, W - Inches per Second) in the Mass Point or Body Coordinate System
MP5	Flag for Angular Velocities (P, Q, R - Radians per Second) in the Mass Point or Body Coordinate System
MP6	Flag for Unfiltered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
MP7	Flag for Filtered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
MP8	Flag for Angular Accelerations (P, Q, R - Radians per Second**2) in the Mass Point or Body Coordinate System
MP9	Flag for Impulse (X, Y, Z in G-sec., P, Q, R in (RAD Per Sec) in Mass Point or Body Coordinate Axes for Filtered Data

REMARKS:

(1) Optional data card(s).
(2) "NMEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "I" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 10I5.

KRASH INPUT DATA

CARDS 4000: MASSLESS NODE POINT PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the massless node point number, mass point number, and flags to specify which massless node point output quantity time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

M	I	NP1	NP2	NP3	NP4	NP5	NP6					
1	7	0	1	0	1	0	0					4000

FIELD	CONTENTS
M	Massless Node Point Number
I	Mass Point Number
NP1	Flag for Linear Displacements (X, Y, Z - Inches) in the Ground Coordinate System
NP2	Flag for Linear Velocities (X, Y, Z - Inches per Second) in the Ground Coordinate System
NP3	Flag for Linear Velocities (U, V, W - Inches per Second) in the Mass Point or Body Coordinate System
NP4	Flag for Unfiltered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
NP5	Flag for Filtered Linear Accelerations (X, Y, Z - G's) in the Mass Point or Body Coordinate System
NP6	Flag for Impulse (X, Y, Z in G-sec. P, Q, R in RAD/Sec) in Mass Point or Body Coordinate System

REMARKS:

(1) Optional data card(s).
(2) "NNEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "M" and "I" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 8I5.

CARDS 4100: BEAM ELEMENT LOADS PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element internal load time histories will be printer plotted.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

I0	BFP1	BFP2	BFP3	BFP4							
27	0	1	0	1							4100

FIELD	CONTENTS
IJ	Beam Element Number
BFP1	Flag for Axial and Shear Forces (FX, FY, FZ - Pounds)
BFP2	Flag for Torque and Bending Moments at End "I" (MX, MY, MZ - Inch * Pounds)
BFP3	Flag for Torque and Bending Moments at End "J" (MX, MY, MZ - Inch * Pounds)
BFP4	Flag for choosing between beam axis loads or loads in mass axes.

REMARKS:

(1) Optional data card(s).
(2) "NBFP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "IJ" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) If BFP4 = 0, then all load data are in the beam element coordinate system shown in Figure 2-5.
If BFP4 = 1, then all load data are in the mass point coordinate system at mass i or j, as appropriate.
(8) If BFP4 = 1, then BFP1 through BFP3 control plotting of the following:
BFP1: FX,FY,FZ at mass I, in mass point coordinate system
BFP2: FX,FY,FZ at mass J, in mass point coordinate system
BFP3: MYI and MYJ, moments about y axis in each mass point coordinate system.
(9) Format for this card is 5I5.

CARDS 4200: BEAM ELEMENT DEFLECTION-ROTATION PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element deflection and rotation time histories will be printer plotted.

FORMAT AND EXAMPLE:

```
0         1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

IJ	BDP1	BDP2	BDP3							
3	0	0	1							4200

FIELD	CONTENTS
IJ	Beam Element Number
BDP1	Flag for Deflection Differences of End “J” and End “1” (X, Y, Z - Inches)
BDP2	Flag for Rotation Differences of End “J” and End “1” (Phi, Theta, Psi - Radians)
BDP3	Flag for Rotation Sums of End “J” and End “I” (Phi, Theta, Psi - Radians)

REMARKS:

(1) Optional data card(s).
(2) “NBDP” on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) “IJ” must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) All deflection-rotation data is output in the beam element coordinate systems shown in Figure 2-3.
(8) Format for this card is 4I5.

CARDS 4300: BEAM ELEMENT STRESS RATIO PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam element stress ratio time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

IJ	STP1	STP2	STP3	STP4	STP5	☒	☒	☒	☒	☒	
7	0	1	1	0	0						4300

FIELD	CONTENTS
IJ	Beam Element Number
STP1	Flag for Stress Ratio for Top and Bottom Fibers Using Maximum Shear Stress Theory
STP2	Flag for Stress Ratio of Left and Right Fibers Using Maximum Shear Stress Theory
STP3	Flag for Stress Ratio of Top and Bottom Fibers using Constant Energy of Distortion Theory
STP4	Flag for Stress Ratio of Left and Right Fibers Using Constant Energy of Distortion Theory
STP5	Flag for Stress Ratio of Tension-Only, Compression-Only, and Axial Buckling Loads

REMARKS:

(1) Optional data card(s).
(2) "NSTP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "IJ" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Stress parameters must be provided for the beam elements on the 0900-series cards.
(8) "NSC" on card 0050 must be flagged "yes."
(9) Format for this card is 6I5.

CARDS 4400: EXTERNAL CRUSHING SPRING LOAD-DEFLECTION PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the end point and flags to specify which external crushing spring load and deflection time histories will be printer plotted.

FORMAT AND EXAMPLE:

0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890

I	M	SEP1	SEP2							
3	1	1	0							4400

FIELD	CONTENTS
I	Mass Point Number
M	Massless Node Point Number
SEP1	Flag for Axial Deflection (Inches)
SEP2	Flag for Axial Loads (Pounds)

REMARKS:

(1) Optional data card(s).
(2) "NSEP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "I" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) All external crushing springs attached to the same mass point/massless node point will be printer plotted if that end point is specified.
(8) Format for this card is 4I5.

CARDS 4500: BEAM ELEMENT STRAIN AND DAMPING ENERGY PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the beam element number and flags to specify which beam internal element strain and damping energy time history will be printer plotted

FORMAT AND EXAMPLE:

<table>
<tr><td colspan="11">0 1 2 3 4 5 6 7 8
12345678901234567890123456789012345678901234567890123456789012345678901234567890</td></tr>
<tr><td>IJ</td><td>ENG1</td><td>ENG2</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td>☒</td><td></td></tr>
<tr><td>2</td><td>1</td><td>1</td><td></td><td></td><td></td><td></td><td></td><td></td><td></td><td>4500</td></tr>
</table>

FIELD	CONTENTS
IJ	Beam Element Number
ENG1	Flag for Strain Energy (in.-lb.)
ENG2	Flag for Damping Energy (in.-lb.)

REMARKS:

(1) Optional data cards.
(2) "NENP" on card 0140 specifies the number of these cards for input.
(3) All entries must be right justified.
(4) "IJ" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) Format for this card is 3I5.

KRASH INPUT DATA

CARDS 4600: DYNAMIC RESPONSE INDEX (DRI) PRINTER PLOT PARAMETERS

DESCRIPTION: Defines the mass point number of a DRI beam element for dynamic response index (DRI) time history printer plots.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

J	☒	☒	☒	☒	☒	☒	☒	☒	
27									**4600**

FIELD	CONTENTS
J	Mass Point Number

REMARKS:
(1) Optional data card(s).
(2) "NDRP" on card 0140 specifies the number of these cards for input.
(3) All entries are right justified integers.
(4) "J" must be nonzero.
(5) Blank entries are read as zero.
(6) Flags for printer plot time histories are defined as follows:
0 = No
1 = Yes
(7) The mass point number must be end "J" of a DRI beam element.
(8) Format for this card is I5.

CARD 4700: END OF DATA

DESCRIPTION: Defines the final card of the input data.

FORMAT AND EXAMPLE:

```
0        1         2         3         4         5         6         7         8
12345678901234567890123456789012345678901234567890123456789012345678901234567890
```

END	
END	**4700**

FIELD	CONTENTS
End	The Mnemonic "End" (Left Justified)

REMARKS: (1) Required data card.

2.3 OUTPUT AND SAMPLE CASE

As explained in Section 2.1, the most general case of a KRASH85 analysis involves the use of three separate programs: KRASHIC, MSCTRAN, and KRASH85. Table 2-6 shows a summary of the output from each program. A sample case which models one-half of a transport airplane with 21 masses and 28 internal beams will be used to illustrate the output for each program. This model is illustrated in figure 2-7. This is a test case with special elements for checkout purposes; it does not represent a realistic airplane model.

TABLE 2-6. SUMMARY OF KRASH85 OUTPUT

KRASHIC

- Echo of input data (2 times)
- Formatted printout of input data
- Miscellaneous calculated data

MSCTRAN

- Executive control deck echo
- Case control deck echo
- Input bulk data deck echo
- Sorted bulk data deck echo
- Displacement vector
- Load vector
- Forces of single-point constraint
- Forces in bar elements
- Element strain energies
- Grid point force balance

KRASH85

- Echo of input data (2 times)
- Formatted printout of input data
- Miscellaneous calculated data
- Time histories of model responses
  - Mass data
  - Internal beam data
  - External spring data
  - Energy data
- Summaries at end of run
  - External spring loading/unloading
  - Summary of plastic hinge formations
  - Summary of internal beam yielding and rupture
  - Summary of energy distribution
  - Interaction load time-histories
  - Vehicle c.g. motion time-histories
  - Time history plots of selected response quantities

2.3.1 KRASHIC Output

2.3.1.1 Echo of Input Data

This is a direct listing of the input data cards for the case being analyzed. Figure 2-8 illustrates this print for the sample case. Each page of the listing is preceded by a heading which identifies the column number. The sequence numbers are in columns 77 - 80. The first card, with a 1 in column 10, is generated by the Job Control Language (JCL), and is not part of the data set (LT.SAMPLE.DATA in this case) in the user's library. This first card tells the program whether or not to read an additional data set of static deflections. A value of 1 means read the additional data set, 0 means don't read it. The JCL is set up to supply a zero for this card for the first iteration, when no static deflection information is available, and a 1 for all subsequent iterations, when the data are available, as generated by NASTRAN. The listing in figure 2-8 is from the last iteration, and therefore the first card has a 1 in column 10. To reiterate, this card is automatically generated by the JCL; the user does not supply this card.

Cards 10 through 3480 are supplied by the user and represent the basic KRASH85 data set described in Section 2.2. This is the data set referred to as XYZ.DATA in Section 2.1. Note how the dummy title cards serve to segment the date and facilitate reviewing and editing the data set.

Following card 3480 is a set of cards numbered 1 through 76. This is the static deflection data set referred to as XYZ.NASOUT.DATA in Section 2.1. The first six cards of this data set are title cards, the remaining cards are the three deflections and three rotations of each grid point in the NASTRAN model used to solve the static loads problem. Cards 1 through 76 are all generated automatically; the user does not have to develop this data set. The data set will reside in the user's library under the name XYZ.NASOUT.DATA.

The complete echo shown in figure 2-8 is provided twice. One copy can be used to mark up for forming a new data set, while the other copy remains as a clean record of the input for the current case.

2.3.1.2 Formatted Print-Out of Input Data

This section of the print output organizes all the input data into logical groups and prints out the data with self-explanatory identification headings. This output is illustrated in figure 2-9 for the sample case. The data are organized into the following major groups:

- Case title cards
- Program size data
- Acceleration data transfer control parameters
- Program data management control data (restart option)
- Program control data
- Vehicle initial conditions
- Initial mass/node point deflections (read from XYZ.NASOUT.DATA)
- Generalized surface data
- Corresponding mass and beam numbering (RUNMOD = 2 only)
- Mass data
- Node point data (optional)
- External spring data (optional)
- Material properties
- Internal beam data
- Unsymmetrical beam data (optional)
- Plastic hinge and end-fixity data (optional)
- Oleo strut beam data (optional)
- Nonlinear beam data (optional)
- Volume penetration data (optional)
- DRI elements (optional)
- Volume change data (optional)
- Nonstandard maximum deflections (optional)
- Nonstandard maximum forces (optional)
- Load interaction curve sign conventions and curve data (optional)
- Nonzero angular momenta, cross-products of inertia, lift constants (optional)

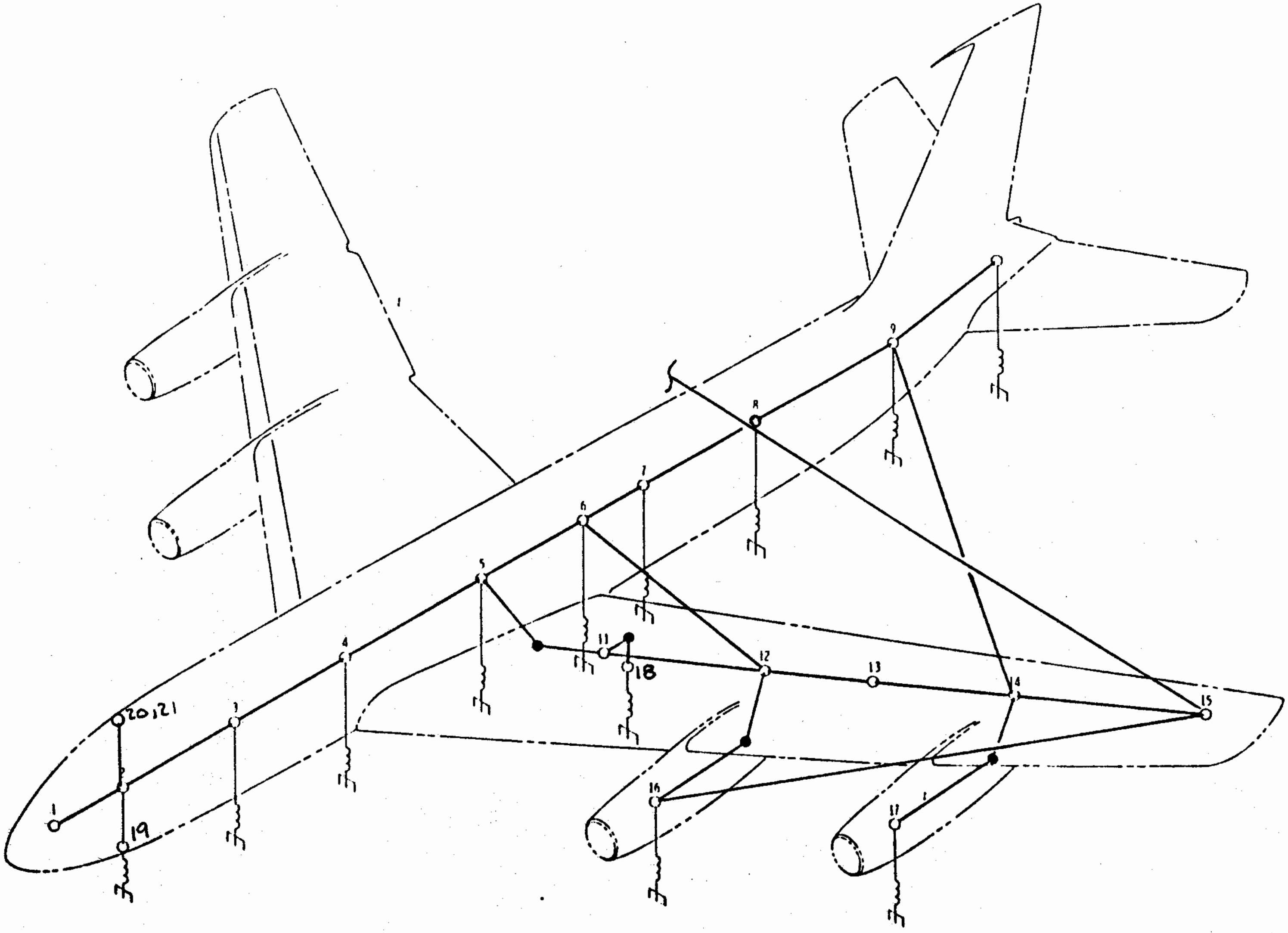


FIGURE 2-7. LARGE TRANSPORT AIRPLANE MODEL - SAMPLE CASE

```
                              ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

      1           1
      2  LT.SAMPLE.DATA                                                          00000010
      3  21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL                 00000020
      4  12345678901234567890123456789012345678901234567890123456789012345678901200000030
      5     NM  NSP   NB  NLB  NNP NPIN  NUB NDRINOLEO NACC  MVP NVCH NMTL   ND  00000040
      6     21   19   28    1   12   10    4    1    2   19    0    0    0    0  00000050
      7   NVBM NFBMNVBMNNFBMN  NKM  NHI  NPH TOL1 TOL2 TOL3  NSC  NICNAERONBOMB  00000060
      8      0    2    0    2    0    2    2 1000 1000 1000    1    1    0    1  00000070
      9   NSCV NLICNWRGR NBAL  ICDICITR                                          00000080
     10      1   15    0    5    1    1                                          00000090
     11  GRAPHICS                                                                00000100
     12                                                                          00000110
     13                                                                     200  00000120
     14  ONE RESTART AND ONE SAVE CARD FOLLOWS                                   00000130
     15                                                                          00000140
     16                                                                          00000150
     17       IPRINT  DELTAT   TMAX     PLOWT     FCUT      RUNMOD               00000160
     18         200  .000050   0.1      0.000     50.        1.                  00000170
     19  BLANK CARD FOLLOWS                                                      00000180
     20                                                                          00000190
     21    NSF  NTF  NDE NSPD  NED   NS  NRP NIMP  NBC : PRINT DATA              00000200
     22      1    1    1    1    1    0    1    0    1                           00000210
     23   NMEP NNEP NBFP NBDP NSTP NSEP NENP NDRP NPLTNPFCT : PLOT DATA          00000220
     24      0    0    6    0    0    0    0    0    0    0                      00000230
     25  INITIAL CONDITION DATA : 3 CARDS                                        00000240
     26     3140.00    000.00    300.00                                          00000250
     27      000.00     0.1      000.00                                          00000260
     28      000.00    .01745    000.00    000.00    000.00      0.001.1463E-07  00000270
     29  MASS DATA : NM CARDS                                                    00000280
     30      1585.0     199.0       0.0     220.0.11514E+05.4    E+05.15   E+05 100000290
     31      9064.5     300.0       0.0     218.7.89080E+05.3    E+06.99   E+05 200000300
     32     15318.1     460.0       0.0     208.7.16278E+06.96935E+05.10309E+06 300000310
     33     13096.0     620.0       0.0     206.0.19627E+06.66715E+05.79389E+05 400000320
     34     21752.6     820.0       0.0     200.2.49106E+06.12567E+06.14651E+06 500000330
     35      7901.5     960.0       0.0     212.4.81383E+05.12   E+06.2    E+06 600000340
     36      9190.7    1040.0       0.0     207.9.87536E+05.14   E+06.2    E+06 700000350
     37      9938.4    1200.0       0.0     225.1.88098E+05.18   E+06.3    E+06 800000360
     38      5702.0    1359.9       0.0     260.0.96249E+05.41788E+05.26039E+05 900000370
     39      6175.2    1570.0       0.0     302.3.21530E+06.10798E+06.15863E+06 1000000380
     40      9670.6     801.3     118.3     188.3.15213E+05.13858E+06.36   E+06 1100000390
     41     10065.6     852.3     271.8     203.1.19510E+05.12263E+06.3    E+06 1200000400
     42      5286.5     943.5     430.7     219.9.72715E+04.52619E+05.11   E+06 1300000410
     43      3759.0    1045.8     583.5     243.5.44083E+04.25823E+05.60   E+05 1400000420
     44      1542.3    1112.6     740.6     255.1.16708E+04.90137E+04.18   E+05 1500000430
     45      5400.0     719.0     321.6     165.8 3651.56   25746.    29374.6  1600000440
     46      5151.0     902.8     551.6     188.1 3712.     24588.2   28178.   1700000450
     47      1922.0     887.0     131.6      90.7 371.     1600.       2000.   1800000460
     48       238.0     279.0       0.0      85.0 24.      300.        500.   1900000470
     49      1000.      300.0       0.0     238.7  1000.     1000.     1000.   2000000480
     50      1000.      300.0       0.0     238.7  1000.     1000.     1000.   2100000490
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 1 OF 9)

```
                          ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

     51  NODE POINT DATA : NNP CARDS                                             00000500
     52      1    5     775.1      48.0     181.0                                00000510
     53      1   11     773.9     118.3     186.3                                00000520
     54      2   11     887.0     131.6     179.7                                00000530
     55      3   11     887.0     131.6     179.7                                00000540
     56      1   12     811.8     321.6     199.6                                00000550
     57      1   14     994.5     551.6     220.5                                00000560
     58      1   15    1148.0     740.6     261.3                                00000570
     59      2   15    1112.6     740.6     255.1                                00000580
     60      1   16     735.7     321.6     199.6                                00000590
     61      2   16     719.0     321.6     165.8                                00000600
     62      1   17     918.4     551.6     220.5                                00000610
     63      1    2     279.0       0.0     147.5                                00000620
     64  EXTERNAL SPRING DATA : 2 X NSP CARDS                                    00000630
     65      1    3      70.       0.35  175000.                                 00000640
     66      2    3      82.7      0.35  300000.0                                00000650
     67      3    3      72.7      0.35  100000.0                                00000660
     68      4    3      70.0      0.35  300000.0                                00000670
     69      5    3      64.2      0.35  300000.0                                00000680
     70      6    3      76.4      0.35  300000.0                                00000690
     71      7    3      69.9      0.35  100000.0                                00000700
     72      8    3      69.1      0.35  100000.0                                00000710
     73      9    3      64.0      0.35  300000.0                                00000720
     74     10    3      82.0      0.35  300000.0                                00000730
     75     11    3      28.       0.35  100000.                                 00000740
     76     12    3      14.       0.35  100000.                                 00000750
     77     13    3      11.       0.35  100000.                                 00000760
     78     14    3       7.       0.35  100000.                                 00000770
     79     15    3        3.      0.35  100000.                                 00000780
     80     16    3      29.8      0.35  272000.                                 00000790
     81     17    3       28.      0.35  272000.                                 00000800
     82     18    3     19.65      0.30  100000.                                 00000810
     83     19    3     16.45      0.30  100000.                                 00000820
     84   1.3      1.5       1.6       10.        70000.    7000.   0.          00000830
     85   1.3      1.5       1.6       10.       140000.   14000.   0.00        00000840
     86   1.0      6.0       10.       21.       115000.   90000.   0.00        00000850
     87   1.0      1.1       2.0       3.0       340000.  200000.   0.00        00000860
     88   1.0      1.1       2.0       3.0       340000.  200000.   0.00        00000870
     89   1.0      1.1       2.0       3.0       340000.  200000.   0.00        00000880
     90   1.       6.        10.       21.        60000.   48000.   0.00        00000890
     91   1.       6.        10.       21.        68000.   48000.   0.00        00000900
     92   1.       1.1       2.0       3.        300000.   30000.   0.00        00000910
     93   1.       1.1       2.0       3.        300000.   30000.   0.00        00000920
     94   1.       1.5       2.        7.        330000.  330000.               00000930
     95   1.       1.5       2.        7.        330000.  330000.   0.00        00000940
     96   1.       1.5       2.        7.        330000.  330000.               00000950
     97   1.       1.5       2.        7.        330000.  330000.               00000960
     98   1.       1.5       2.        7.        330000.  330000.   0.00        00000970
     99   1.       8.        9.        16.        10000.   30000.               00000980
    100   1.       8.        9.        16.        10000.   30000.               00000990
    101   2.       2.001     8.05      8.051      62200.  294700.     .02       00001000
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 2 OF 9)

```
                          ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    102    2.      2.001     5.75      5.751      16150.    51500.     .02       00001010
    103  INTERNAL BEAM DATA : NB CARDS                                           00001020
    104      1    2     32.00      0.00  6.20E+04  3.70E+04      0.00 96.0 96.0 500001030
    105      2    3     36.00      0.00  7.70E+04  4.30E+04      0.00 99.0 99.0 500001040
    106      3    4     36.00      0.00  8.60E+04  4.30E+04      0.00 56.0 56.0 500001050
    107      4    5     59.00      0.00 13.60E+04  4.65E+04      0.00 56.0 56.0 500001060
    108      5    6     59.00      0.00 11.60E+04  4.65E+04      0.00 66.0 66.0 500001070
    109      6    7     57.00      0.00 13.60E+04  5.70E+04      0.00 88.0 88.0 500001080
    110      7    8     48.00      0.00 11.40E+04  6.20E+04      0.00 91.0 91.0 500001090
    111      8    9     37.00      0.00  5.60E+04  3.35E+04      0.00 51.0 51.0 500001100
    112      9   10     25.00      0.00  9.00E+04  9.50E+03      0.00 50.0 50.0 500001110
    113      5 1 11     54.00 4.800E+04  1.59E+04  1.14E+05      0.00  1.0  1.0 500001120
    114   1 11   12     63.20 2.600E+04  1.14E+04  1.02E+05      0.00  1.0  1.0 500001130
    115     12   13     56.3  1.000E+04  4.70E+03  5.80E+04      0.00  1.0  1.0 500001140
    116     13   14     40.7  4.800E+03  2.00E+03  2.10E+04      0.00  1.0  1.0 500001150
    117     14 1 15     20.   2.700E+03  1.20E+03  8.00E+03      0.00  1.0  1.0 500001160
    118   1 12 1 16      8.0  2.208E+02  7.32E+02  1.00E+02      0.00  1.0  1.0 400001170
    119   1 14 1 17      8.0  2.208E+02  7.32E+02  1.00E+02      0.00  1.0  1.0 400001180
    120   2 11   18      0.01 150.0      239.E+00  239.E+00      0.00  1.0  1.0 100001190
    121   3 11   18    0.01   150.0      239.E+00  239.E+00      0.00  1.0  1.0 100001200
    122   1  2   19      0.01   5.       32.5E+00  32.5E+00      0.00  1.0  1.0 100001210
    123      6   12     40.7  4.800E+03  2.00E+03  2.10E+04      0.00  1.0  1.0 500001220
    124      9   14     40.7  4.800E+03  2.00E+03  2.10E+04      0.00  1.0  1.0 500001230
    125     12    0     40.7  4.800E+03  2.00E+03  2.10E+04      0.00  1.0  1.0 500001240
    126      2   20     10.     1.0        1.0       1.0         0.00  1.0  1.0 900001250
    127      2   21     10.     1.0        1.0       1.0         0.00  1.0  1.01000001260
    128     15   16     20.                                      0.00  1.0  1.0 500001270
    129   2 15 2 16     20.                                      0.00  1.0  1.0 500001280
    130     15    0     20.   2.700E+03  1.20E+03  8.00E+03      0.00  1.0  1.0 500001290
    131   2 15    0     20.   2.700E+03  1.20E+03  8.00E+03      0.00  1.0  1.0 500001300
    132  BEAM END FIXITY CARDS: NPIN CARDS                                       00001310
    133      1    2    0    0    1    1    0.          0.    0.0088     1.15      00001320
    134      2    3    0    0    1    1    0.          0.    1.25       1.25      00001330
    135      3    4    0    0    1    1    0.          0.    1.1        1.1       00001340
    136      4    5    0    0    1    1    0.          0.    1.15       1.15      00001350
    137      5    6    0    0    1    1    0.          0.    1.25       1.25      00001360
    138      6    7    0    0    1    1    0.          0.    1.25       1.25      00001370
    139      7    8    0    0    1    1    0.          0.    1.15       1.15      00001380
    140      8    9    0    0    1    1    0.          0.    1.0        1.0       00001390
    141      6   12    0    0    1    1    0.          0.    0.         0.        00001400
    142      9   14    0    1    0    1    0.          0.    0.         0.        00001410
    143  UNSYM BEAM DATA:  NUB CARDS                                             00001420
    144     15   16    1         .08                                             00001430
    145   2 15 2 16   -1         .08                                             00001440
    146     15    0    1         .3                                              00001450
    147   2 15    0   -1         .3                                              00001460
    148  OLEO BEAM CARDS:                                                        00001470
    149          1.         1                                                    00001480
    150   2 11   18   20.982  10855.       739.    1.4       20.                 00001490
    151   1  2   19   16.965   3420.       289.    1.4       16.                 00001500
    152   2 11   18    4.0        0.        .1E06     .1E06   5000.           1  00001510
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 3 OF 9)

```
                         ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

   153    1  2   19    3.4        0.       50.E03    50.E03    500.              00001520
   154           45                                                              00001530
   155     -0.2      352.7                                                       00001540
   156     -0.0964   352.7                                                       00001550
   157     -0.0376    10.24                                                      00001560
   158      0.124     23.62                                                      00001570
   159      0.341     22.21                                                      00001580
   160      0.607     17.90                                                      00001590
   161      0.953      8.24                                                      00001600
   162      1.46       3.38                                                      00001610
   163      2.17       2.13                                                      00001620
   164      3.07       1.25                                                      00001630
   165      4.13       1.56                                                      00001640
   166      5.21       1.79                                                      00001650
   167      6.20       2.46                                                      00001660
   168      7.05       3.58                                                      00001670
   169      7.72       6.26                                                      00001680
   170      8.20      13.47                                                      00001690
   171      8.53      31.50                                                      00001700
   172      8.74      62.40                                                      00001710
   173      8.91      64.06                                                      00001720
   174      9.12      34.22                                                      00001730
   175      9.41      16.03                                                      00001740
   176      9.83       8.42                                                      00001750
   177     10.39       5.24                                                      00001760
   178     11.08       3.68                                                      00001770
   179     11.87       2.93                                                      00001780
   180     12.71       2.77                                                      00001790
   181     13.54       3.38                                                      00001800
   182     14.27       4.93                                                      00001810
   183     14.83       9.33                                                      00001820
   184     15.21      25.53                                                      00001830
   185     15.40     153.79                                                      00001840
   186     15.4518  1000.                                                        00001850
   187     15.4539  1000.                                                        00001860
   188     15.4581  1000.                                                        00001870
   189     15.494   403.85                                                       00001880
   190     15.61     67.70                                                       00001890
   191     15.84     22.15                                                       00001900
   192     16.18      9.93                                                       00001910
   193     16.65      5.31                                                       00001920
   194     17.21      3.02                                                       00001930
   195     17.82      2.07                                                       00001940
   196     18.39      0.92                                                       00001950
   197     18.82      0.                                                         00001960
   198     18.97     10.                                                         00001970
   199     22.       10.                                                         00001980
   200   DAMPC CARD                                                              00001990
   201    .05                                                                    00002000
   202   NONLINEAR BEAM DATA: NLB + CARDS                                        00002010
   203    3 11   18    1    7   2.0                                              00002020
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 4 OF 9)

```
                              ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    204  DRI CARD:                                                               00002030
    205      2   21                                                              00002040
    206  POS.FORCE CUTOFF:NFBM CARDS                                             00002050
    207   2 11    18    428000     1.E10    1.0E10     1.E10     1.E10     1.E10  00002060
    208   1  2   19    130000     1.E10     78000     1.E10     1.E10     1.E10  00002070
    209  NEG.FORCE CUTOFF:NFBMN CARDS                                            00002080
    210   2 11    18    428000     1.E10    1.0E10     1.E10     1.E10     1.E10  00002090
    211   1  2   19    130000     1.E10     78000     1.E10     1.E10     1.E10  00002100
    212  LOAD INTERACTION SIGN CONVENTIONS(NSCV CARDS):                          00002110
    213      1    2   -3    4    5    6                                          00002120
    214  LOAD INTERACTION DATA(NLIC+ CARDS):                                     00002130
    215      1    3    5    1    0       300.                           1000.    00002140
    216                                 166000.    20.8E+06 -166000.  -20.8E+06  00002150
    217      1    1 199000.   45.6 E+06                                          00002160
    218      2    3    5    1    0       300.                           1000.    00002170
    219                                 166000.    20.8E+06 -166000.  -20.8E+06  00002180
    220      1    1 199000.   45.6 E+06                                          00002190
    221      2    3    5    2    0       400.                           1000.    00002200
    222                                 210000.    23.8E+06 -210000.  -23.8E+06  00002210
    223      1    1 185000.   60.8 E+06                                          00002220
    224      1    1 674300.   25.4 E+06                                          00002230
    225      3    3    5    2    0       480.                           1000.    00002240
    226                                                                          00002250
    227      1    1 195000.  130.3 E+06                                          00002260
    228      1    1 545300.   28.9 E+06                                          00002270
    229      3    3    5    2    0       540.                           1000.    00002280
    230                                                                          00002290
    231      1    1 199000.  137.3 E+06                                          00002300
    232      1    11365380.   35.3 E+06                                          00002310
    233      3    3    5    2    0       620.                           1000.    00002320
    234                                 274000.    45.0E+06 -274000.  -45.0E+06  00002330
    235      1    1 286000.  185.6 E+06                                          00002340
    236      1    1 384400.   79.7 E+06                                          00002350
    237      4    3    5    2    0       620.                           1000.    00002360
    238                                 274000.    45.0E+06 -274000.  -45.0E+06  00002370
    239      1    1 286000.  185.6 E+06                                          00002380
    240      1    1 384400.   79.7 E+06                                          00002390
    241      5    3    5    2    1       960.                           1000.    00002400
    242                                 288000.             -288000.             00002410
    243      1    0-5.2317E06  71.5E+06                                          00002420
    244      1    1 474500.  152.8E+06                                          00002430
    245      6    3    5    2    1       960.                           1000.    00002440
    246                                 288000.             -288000.             00002450
    247      1    0-5.2317E06  71.5E+06                                          00002460
    248      1    1 474500.  152.8E+06                                          00002470
    249      6    3    5    2    1      1000.                           1000.    00002480
    250                                 254000.    74.0E+06 -254000.  -74.0E+06  00002490
    251      1    1 301000.  228.7E+06                                          00002500
    252      1    11.3581E 06  84.2E+06                                          00002510
    253      7    3    5    3    1      1080.                           1000.    00002520
    254                                                                          00002530
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 5 OF 9)

```
                           ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    255      0    1 210000.  -555.88E06                                          00002540
    256      1    1 327700.   107.75E06                                          00002550
    257      1    1 1.5738E06  64.0 E06                                          00002560
    258      7    3    5    3    1      1160.                           1000.    00002570
    259                                                                          00002580
    260      0    1 239000.  -265.64E06                                          00002590
    261      1    1 372214.    83.5E 06                                          00002600
    262      1    1 804840.    49.9E 06                                          00002610
    263      8    3    5    3    1      1240.                           1000.    00002620
    264                                          35.0  E 06            -35.0E06  00002630
    265      0    1 198000.  -217.32E06                                          00002640
    266      1    1 409460.    50.5E 06                                          00002650
    267      1    1 965217.    37.0E 06                                          00002660
    268      8    3    5    2    1      1320.                           1000.    00002670
    269                                          27.2  E 06            -27.2E06  00002680
    270      0    1 148000.  -91.818E06                                          00002690
    271      1    1 662500.    31.8E 06                                          00002700
    272      9    3    5    3    1      1400.                           1000.    00002710
    273                                                                          00002720
    274      0    1 123500.  -54.998E06                                          00002730
    275      1    1 350720.    24.2E 06                                          00002740
    276      1    1 914520.    18.9E 06                                          00002750
    277  NONZERO ANGULAR MOMENTA (NHI CARDS):                                    00002760
    278  16          .1   E06                                                    00002770
    279  17          .1   E06                                                    00002780
    280  NONZERO MASS ORIENTATION ANGLES (NPH CARDS):                            00002790
    281     16     -.0872665  .0349066  .05236                                   00002800
    282     17     -.0872665  .0349066  .05236                                   00002810
    283  FORCE TIME HISTORY DATA: NACC + CARDS                                   00002820
    284      1    3    2    1                                                    00002830
    285      2    3    2    1                                                    00002840
    286      3    3    2    1                                                    00002850
    287      4    3    2    1                                                    00002860
    288      5    3    2    1                                                    00002870
    289      6    3    2    1                                                    00002880
    290      7    3    2    1                                                    00002890
    291      8    3    2    1                                                    00002900
    292      9    3    2    1                                                    00002910
    293     10    3    2    1                                                    00002920
    294     11    3    2    1                                                    00002930
    295     12    3    2    1                                                    00002940
    296     13    3    2    1                                                    00002950
    297     14    3    2    1                                                    00002960
    298     15    3    2    1                                                    00002970
    299     16    3    2    1                                                    00002980
    300     17    3    2    1                                                    00002990
    301     18    3    2    1                                                    00003000
    302     19    3    2    1                                                    00003010
    303     0.          -95.                                                     00003020
    304     1.          -95.                                                     00003030
    305     0.         -624.5                                                    00003040
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 6 OF 9)

```
                              ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    306     1.         -624.5                                                    00003050
    307     0.        -1861.                                                     00003060
    308     1.        -1861.                                                     00003070
    309     0.        -4715.                                                     00003080
    310     1.        -4715.                                                     00003090
    311     0.        -7901.                                                     00003100
    312     1.        -7901.                                                     00003110
    313     0.        -1991.                                                     00003120
    314     1.        -1991.                                                     00003130
    315     0.        -2316.                                                     00003140
    316     1.        -2316.                                                     00003150
    317     0.         -785.4                                                    00003160
    318     1.         -785.4                                                    00003170
    319     0.         -450.                                                     00003180
    320     1.         -450.0                                                    00003190
    321     0.        17445.6                                                    00003200
    322     1.        17445.6                                                    00003210
    323     0.       -15419.2                                                    00003220
    324     1.       -15419.2                                                    00003230
    325     0.       -28188.2                                                    00003240
    326     1.       -28188.2                                                    00003250
    327     0.       -21394.1                                                    00003260
    328     1.       -21394.1                                                    00003270
    329     0.       -17818.8                                                    00003280
    330     1.       -17818.8                                                    00003290
    331     0.        -6240.9                                                    00003300
    332     1.        -6240.9                                                    00003310
    333     0.         -270.8                                                    00003320
    334     1.         -270.8                                                    00003330
    335     0.         -258.3                                                    00003340
    336     1.         -258.3                                                    00003350
    337     0.            0.                                                     00003360
    338     1.            0.                                                     00003370
    339     0.            0.                                                     00003380
    340     1.            0.                                                     00003390
    341  BEAM LOAD PLOT PARAMETERS:  NBFP CARDS                                  00003400
    342      3    1    1    1    0                                               00003410
    343      7    1    1    1    1                                               00003420
    344     11    1    1    1    0                                               00003430
    345     11    1    1    1    1                                               00003440
    346     12    1    1    1    1                                               00003450
    347     14    1    1    1    0                                               00003460
    348  END                                                                     00003470
    349  $TITLE   =LT.SAMPLE.DATA                                                       1
    350  $SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL              2
    351  $LABEL   =INITIAL CONDITION STATIC SOLUTION                                    3
    352  $DISPLACEMENTS                                                                 4
    353  $REAL OUTPUT                                                                   5
    354  $SUBCASE ID =           1                                                      6
    355         100       G     -3.089143E-02      0.0              -9.927106E-01       7
    356  -CONT-                  0.0              -2.240265E-03      0.0                8
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 7 OF 9)

```
                        ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    357          200       G      -2.848941E-02    0.0            -7.668377E-01         9
    358  -CONT-                    0.0            -2.228401E-03    0.0                 10
    359          201       G       1.302763E-01    0.0            -8.132805E-01        11
    360  -CONT-                    0.0            -2.228401E-03    0.0                 12
    361          300       G      -7.956207E-03    0.0            -4.223564E-01        13
    362  -CONT-                    0.0            -2.016658E-03    0.0                 14
    363          400       G      -3.881566E-03    0.0            -1.467094E-01        15
    364  -CONT-                    0.0            -1.310210E-03    0.0                 16
    365          500       G       0.0             0.0             0.0                 17
    366  -CONT-                    0.0             0.0             0.0                 18
    367          501       G       0.0             0.0             0.0                 19
    368  -CONT-                    0.0             0.0             0.0                 20
    369          600       G       3.900044E-04    0.0            -1.395651E-01        21
    370  -CONT-                    0.0             1.905726E-03    0.0                 22
    371          700       G      -1.741045E-02    0.0            -3.224223E-01        23
    372  -CONT-                    0.0             2.646158E-03    0.0                 24
    373          800       G       1.960037E-02    0.0            -8.574680E-01        25
    374  -CONT-                    0.0             3.925510E-03    0.0                 26
    375          900       G       1.623369E-01    0.0            -1.646019E+00        27
    376  -CONT-                    0.0             5.791210E-03    0.0                 28
    377         1000       G       4.121330E-01    0.0            -2.947555E+00        29
    378  -CONT-                    0.0             6.380443E-03    0.0                 30
    379         1100       G      -2.376708E-02   -6.204829E-02    4.549811E-01        31
    380  -CONT-                   -6.692741E-03   -2.201437E-03   -5.605556E-04        32
    381         1101       G      -1.923054E-02   -6.048076E-02    3.946611E-01        33
    382  -CONT-                   -6.692741E-03   -2.201437E-03   -5.605556E-04        34
    383         1102       G      -1.296112E-02   -1.657883E-01    7.333756E-01        35
    384  -CONT-                   -6.692741E-03   -2.201437E-03   -5.605556E-04        36
    385         1103       G      -1.296112E-02   -1.657883E-01    7.333756E-01        37
    386  -CONT-                   -6.692741E-03   -2.201437E-03   -5.605556E-04        38
    387         1199       G      -9.159952E-02    0.0             5.671605E-01        39
    388  -CONT-                    0.0            -6.671570E-03    0.0                 40
    389         1200       G      -2.183183E-01    4.138300E-02    2.341778E+00        41
    390  -CONT-                   -1.306025E-02   -6.671570E-03   -9.325834E-04        42
    391         1201       G      -2.439489E-01    3.842940E-02    2.721848E+00        43
    392  -CONT-                   -1.306025E-02   -6.671570E-03   -9.325834E-04        44
    393         1300       G      -6.008096E-01    3.054580E-01    6.170235E+00        45
    394  -CONT-                   -2.241265E-02   -1.032134E-02   -1.681539E-03        46
    395         1400       G      -1.368592E+00    6.399863E-01    1.084585E+01        47
    396  -CONT-                   -2.562700E-02   -7.394243E-03   -5.296096E-03        48
    397         1401       G      -1.022668E+00    2.900483E-01    9.660551E+00        49
    398  -CONT-                   -2.562700E-02   -7.394243E-03   -5.296096E-03        50
    399         1498       G      -6.724822E-01    0.0             8.267696E+00        51
    400  -CONT-                    0.0            -9.067804E-03    0.0                 52
    401         1499       G      -6.724822E-01    0.0             8.267696E+00        53
    402  -CONT-                    0.0            -9.067804E-03    0.0                 54
    403         1500       G      -2.495207E+00    4.342729E-01    1.459589E+01        55
    404  -CONT-                   -1.709940E-02   -9.067804E-03   -4.925180E-03        56
    405         1501       G      -2.554651E+00    3.717276E-01    1.491743E+01        57
    406  -CONT-                   -1.709940E-02   -9.067804E-03   -4.925180E-03        58
    407         1502       G      -2.495207E+00    4.342729E-01    1.459589E+01        59
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 8 OF 9)

```
                              ECHO OF THE INPUT DATA IN CARD IMAGE FORMAT

                  1         2         3         4         5         6         7         8
CARD NO. 12345678901234567890123456789012345678901234567890123456789012345678901234567890

    408  -CONT-                 -1.709940E-02     -9.067804E-03     -4.925180E-03      60
    409        1600       G      7.919735E-02     -2.893812E-01      1.937819E+00      61
    410  -CONT-                 -1.295901E-02     -9.379078E-03     -1.573280E-03      62
    411        1601       G     -2.385548E-01      1.247810E-01      2.086104E+00      63
    412  -CONT-                 -1.295901E-02     -9.379078E-03     -1.573280E-03      64
    413        1602       G      7.919735E-02     -2.893812E-01      1.937819E+00      65
    414  -CONT-                 -1.295901E-02     -9.379078E-03     -1.573280E-03      66
    415        1700       G     -6.952552E-01     -3.464461E-02      8.834676E+00      67
    416  -CONT-                 -2.537085E-02     -9.936552E-03     -5.952675E-03      68
    417        1701       G     -1.014152E+00      6.997874E-01      8.967885E+00      69
    418  -CONT-                 -2.537085E-02     -9.936552E-03     -5.952675E-03      70
    419        1800       G      1.832870E-01     -7.628592E-01      6.225001E-01      71
    420  -CONT-                 -6.689243E-03     -2.204068E-03     -5.605288E-04      72
    421        1900       G      2.696309E-01      0.0              -8.798568E-01      73
    422  -CONT-                  0.0              -2.223161E-03      0.0               74
    423        2000       G     -9.809875E-02      0.0              -8.621072E-01      75
    424  -CONT-                  0.0              -4.137885E-03      0.0               76
    425        2100       G     -7.305723E-02      0.0              -7.669372E-01      77
    426  -CONT-                  0.0              -2.228401E-03      0.0               78
```

FIGURE 2-8. ECHO OF THE INPUT DATA (SHEET 9 OF 9)

```
LT.SAMPLE.DATA
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

PROGRAM SIZE DATA

NUMBER OF:
                                NON-                                             NON-     NON-
                                ZERO                                           STANDARD STANDARD NON-    NON-             NO.
                          KR    HE OR    MASS   VOLUME   DRI     MTL    ACCEL.   MAX.     MAX.  ZERO  STANDARD STIFFNESS NODE
MASSES  SPRINGS  BEAMS  TABLES   IXY    PENETR. CHANGE ELEMENTS TYPES   TABLES  DEFL.    FORCE  PHI''  DAMPING  MATRICES PTS.
                                                                                 NVB      NFB
  NM      NSP     NB     NLB     NHI     MVP     NVCH    NDRI   NMTL     NACC   +   -   +   -    NPH      ND       NKM    NNP
  21      19      28      1       2       0       0        1      0       19    0   0   2   2     21       0        0      12

 NSC=    1    NIC=     1    NTOL1= 1000%     NTOL2= 1000%     NTOL3= 1000%

 NO.OF OLEO STRUTS=    2     ALPHA= 1.000D 00

 NAERO =  0     RHO =    1.14630D-07


ACCELERATION DATA TRANSFER CONTROL PARAMETERS

       REUSE: TITLE      -               SAVE: TITLE  -
              CASE       -      0              CASE   -      0
              NO. TABLES -      0              NMSAV  -      0
                                               NNPSAV -      0
                                               NDTSAV -      0
                                               NWRFLG -      0
                                               NDTGRA -


 PROGRAM DATA MANAGEMENT CONTROL DATA

          RESTART: TITLE -                      SAVE: TITLE -
                   CASE  -    0                       CASE  -    0
                   TIME  -    0                       TIMES -    0   0   0   0   0


 VARIABLE INTEGRATION CONTROL DATA

    VAR. INT. FLAG = 0  EL =  0.0    EU =  0.0    LOWER RATIO =  0.0  UPPER RATIO =  0.0


PROGRAM CONTROL DATA

  PRINT INTERVAL/            INTEGRATION         MAX.         PLOW FORCE          FILTER CUTOFF       CASE TYPE
INTEGRATION INTERVAL          INTERVAL           TIME        STARTING TIME          FREQUENCY         INDICATOR

        DP/DT                    DT              TMAX            PLOWT                FCUT              RUNMOD
         200                  0.000050         0.100000           0.0                50.000              1.000


TIME HISTORY PRINT CONTROL CARDS

 STRAIN   TOTAL   BEAM      EXT.SPRING  ENERGY  STRESS  ACCEL  IMPULSE
 FORCES  FORCES DEFLECTIONS    DATA      DATA    DATA   DATA    DATA
     1       1        1           1          1       0      1       0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 1 OF 16)

```
NO.MASS POSITION PLOTS


VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

        XGDOT              YGDOT              ZGDOT
          P'                 Q'                 R'
         PHI'              THETA'              PSI'

      3.14000D 03        0.0                3.00000D 02
      0.0                1.00000D-01        0.0
      0.D                1.74500D-02        0.0


INITIAL MASS POINT DEFLECTIONS

 I      DXAP(I)       DYAP(I)         DZAP(I)       DPHAP(I)        DTHAP(I)       DPSAP(I)          I
 1    3.089143D-02   0.0             9.927106D-01   0.0            -2.240265D-03   0.0               1
 2    2.848941D-02   0.0             7.668377D-01   0.0            -2.228401D-03   0.0               2
 3    7.956207D-03   0.0             4.223564D-01   0.0            -2.016658D-03   0.0               3
 4    3.881566D-03   0.0             1.467094D-01   0.0            -1.310210D-03   0.0               4
 5    0.0            0.0             0.0            0.0             0.0            0.0               5
 6   -3.900044D-04   0.0             1.395651D-01   0.0             1.905726D-03   0.0               6
 7    1.741045D-02   0.0             3.224223D-01   0.0             2.646158D-03   0.0               7
 8   -1.960037D-02   0.0             8.574680D-01   0.0             3.925510D-03   0.0               8
 9   -1.623369D-01   0.0             1.646019D 00   0.0             5.791210D-03   0.0               9
10   -4.121330D-01   0.0             2.947555D 00   0.0             6.380443D-03   0.0              10
11    2.376708D-02  -6.204829D-02   -4.549811D-01   6.692741D-03   -2.201437D-03   5.605556D-04     11
12    2.183183D-01   4.138300D-02   -2.341778D 00   1.306025D-02   -6.671570D-03   9.325834D-04     12
13    6.008096D-01   3.054580D-01   -6.170235D 00   2.241265D-02   -1.032134D-02   1.681539D-03     13
14    1.368592D 00   6.399863D-01   -1.084585D 01   2.562700D-02   -7.394243D-03   5.296096D-03     14
15    2.495207D 00   4.342729D-D1   -1.459589D 01   1.709940D-02   -9.067804D-03   4.925180D-03     15
16   -7.919735D-02  -2.893812D-01   -1.937819D 00   1.295901D-02   -9.379078D-03   1.573280D-03     16
17    6.952552D-01  -3.464461D-02   -8.834676D 00   2.537085D-02   -9.936552D-03   5.952675D-03     17
18   -1.832870D-01  -7.628592D-01   -6.225001D-01   6.689243D-03   -2.204068D-03   5.605288D-04     18
19   -2.696309D-01   D.0             8.798568D-01   0.0            -2.223161D-03   0.0              19
20    9.809875D-02   0.0             8.621072D-01   0.0            -4.137885D-03   0.0              20
21    7.305723D-02   0.0             7.669372D-01   0.0            -2.228401D-03   0.0              21


INITIAL NODE POINT DEFLECTIONS

 I  M      DXNPAP          DYNPAP          DZNPAP
 5  1    0.0             0.0             0.0
11  1    1.923054D-02   -6.048076D-02   -3.946611D-01
11  2    1.296112D-02   -1.657883D-01   -7.333756D-01
11  3    1.296112D-02   -1.6578830-01   -7.333756D-01
12  1    2.439489D-01    3.842940D-02   -2.721848D 00
14  1    1.022668D 00    2.900483D-01   -9.6605510 00
15  1    2.554651D 00    3.717276D-01   -1.491743D 01
15  2    2.495207D 00    4.342729D-01   -1.4595890 01
16  1    2.385548D-01    1.247810D-01   -2.0861040 00
16  2   -7.919735D-02   -2.893812D-01   -1.937819D 00
17  1    1.0141520 00    6.997874D-01   -8.967885D 00
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 2 OF 16)

```
 2  1  -1.302763D-01   0.0            8.132805D-01

GENERALIZED SURFACE DATA

BETA =   0.0 DEGREES
XGIN =   D.0
ZGIN =   0.0


MASS DATA


        WEIGHTS           MASS COORDINATES F.S.,B.L.,W.L.           MASS MOMENTS OF INERTIA (LB-IN-SEC**2)

 I         W              X''            Y''                Z''            IX             IY             IZ            I
 1    1.58500D 03    1.98969D 02    0.0               2.19D07D 02    1.15140D 04    4.00000D 04    1.5D000D 04      1
 2    9.06450D 03    2.99972D 02    0.0               2.17933D 02    8.90800D 04    3.00000D 05    9.90000D 04      2
 3    1.53181D 04    4.59992D 02    0.0               2.08278D 02    1.62780D 05    9.69350D 04    1.03090D 05      3
 4    1.30960D 04    6.19996D 02    0.0               2.05853D 02    1.96270D 05    6.67150D 04    7.93890D 04      4
 5    2.17526D 04    8.20000D 02    0.0               2.0020DD 02    4.91060D D5    1.25670D 05    1.46510D 05      5
 6    7.90150D 03    9.60000D 02    0.0               2.12260D 02    8.13830D 04    1.20000D D5    2.00000D 05      6
 7    9.19070D 03    1.03998D 03    0.0               2.07578D 02    8.75360D 04    1.40000D D5    2.00000D 05      7
 8    9.93840D 03    1.20002D 03    0.0               2.24243D 02    8.80980D 04    1.80000D 05    3.00000D 05      8
 9    5.70200D 03    1.36006D 03    0.0               2.58354D 02    9.62490D 04    4.178800 04    2.60390D 04      9
10    6.17520D 03    1.57041D 03    0.0               2.99352D 02    2.15300D 05    1.07980D 05    1.58630D 05     10
11    9.67060D 03    8.01276D 02    1.18362D 02       1.88755D 02    1.52130D 04    1.38580D 05    3.60000D 05     11
12    1.00656D 04    8.52082D 02    2.71759D 02       2.05442D 02    1.95100D 04    1.22630D 05    3.00000D 05     12
13    5.28650D 03    9.42899D 02    4.303950 D2       2.26070D 02    7.27150D 03    5.26190D 04    1.1000DD 05     13
14    3.75900D 03    1.04443D 03    5.82860D 02       2.54346D D2    4.40830D D3    2.58230D 04    6.00000D 04     14
15    1.54230D 03    1.11010D 03    7.40166D 02       2.69696D 02    1.67080D 03    9.01370D 03    1.80000D 04     15
16    5.40000D 03    7.19079D 02    3.21889D 02       1.67738D 02    3.65156D 03    2.57460D 04    2.93746D 04     16
17    5.15100D 03    9.02105D 02    5.516350 02       1.96935D 02    3.71200D 03    2.45882D 04    2.81780D 04     17
18    1.92200D 03    8.87183D 02    1.32363D 02       9.13225D 01    3.71000D 02    1.60000D 03    2.00000D 03     18
19    2.38000D 02    2.79270D 02    0.0               8.41201D 01    2.40000D 01    3.0D000D 02    5.00000D 02     19
20    1.00000D 03    2.99902D 02    0.0               2.37838D 02    1.00000D 03    1.00000D 03    1.00000D 03     20
21    1.00000D 03    2.99927D 02    0.0               2.37933D 02    1.00000D 03    1.00000D 03    1.00000D 03     21


NODE POINT DATA

  MASS   N.P.     NODE POINT COORDINATES F.S.,B.L.,W.L.
    I     M         X''            Y''             Z''
    5     1    7.75100D 02    4.8D000D 01    1.81D00D 02
   11     1    7.73881D 02    1.18360D 02    1.86695D 02
   11     2    8.86987D 02    1.31766D 02    1.80433D 02
   11     3    8.86987D 02    1.31766D 02    1.80433D 02
   12     1    8.11556D 02    3.21562D 02    2.D2322D 02
   14     1    9.93477D 02    5.51310D 02    2.30161D 02
   15     1    1.14545D 03    7.40228D 02    2.76217D 02
   15     2    1.11010D 03    7.40166D 02    2.69696D 02
   16     1    7.35461D 02    3.21475D 02    2.01686D 02
   16     2    7.19D79D 02    3.21889D 02    1.67738D 02
   17     1    9.17386D 02    5.50900D 02    2.29468D 02
    2     1    2.79130D 02    0.0            1.46687D 02


EXTERNAL SPRING DATA
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 3 OF 16)

```
               FREE         FRICTION       BOTTOMING       PLOWING        GROUND
   SPRING     LENGTH       COEFFICIENT      SPRING         FORCE        FLEXIBILITY

 I  K  M     LBAR(IKM)      MU(IKM)        KE(IKM)        FORCE(IKM)     GFLEX(IKM)
 1  3  0    7.00000D 01    3.50000D-01    1.75000D 05    D.0            0.0
 2  3  0    8.27000D 01    3.50000D-01    3.00000D 05    0.0            D.0
 3  3  0    7.27000D 01    3.50000D-01    1.00000D 05    0.0            0.0
 4  3  0    7.00000D 01    3.50000D-01    3.00000D 05    0.0            0.0
 5  3  0    6.42000D 01    3.50000D-01    3.00000D 05    0.0            0.0
 6  3  0    7.64000D 01    3.50000D-01    3.00000D 05    0.0            0.0
 7  3  0    6.99000D 01    3.50000D-01    1.00000D 05    0.0            0.0
 8  3  0    6.91000D 01    3.50000D-01    1.00000D 05    0.0            0.0
 9  3  0    6.40000D 01    3.50000D-01    3.00000D 05    0.0            0.0
10  3  0    8.20000D 01    3.50000D-01    3.00000D 05    0.0            0.0
11  3  0    2.80000D 01    3.50000D-01    1.00000D 05    0.0            0.0
12  3  0    1.40000D 01    3.50000D-01    1.00000D 05    0.0            0.0
13  3  0    1.10000D 01    3.50000D-01    1.00000D 05    D.0            0.0
14  3  0    7.00000D 00    3.50000D-01    1.00000D 05    0.0            0.0
15  3  0    3.00000D 00    3.50000D-01    1.00000D 05    0.0            0.0
16  3  0    2.98000D 01    3.50000D-01    2.72000D 05    0.0            0.0
17  3  0    2.80000D 01    3.50000D-01    2.72000D 05    0.0            0.0
18  3  0    1.96500D 01    3.00000D-01    1.00000D 05    0.0            0.0
19  3  0    1.64500D 01    3.00000D-01    1.00000D 05    0.0            0.0

SPRING                       DEFLECTION COORDINATES                      SPRING AXIAL FORCES

 I  K  M      SI(IKM)        SA(IKM)        SB(IKM)        SF(IKM)       FSPOI(IKM)     FSPOF(IKM)      CRIT.DAMP    CDAMP(IKM)
 1  3  0    1.30000D 00    1.50000D 00    1.60000D 00    1.00000D 01    7.00000D 04    7.00000D 03    0.0            0.0
 2  3  D    1.30000D 00    1.50000D 00    1.60000D 00    1.00000D 01    1.40000D 05    1.40000D 04    0.0            0.0
 3  3  0    1.00000D 00    6.00000D 00    1.00000D 01    2.10000D 01    1.15000D 05    9.00000D 04    0.0            0.0
 4  3  0    1.00000D 00    1.10000D 00    2.00000D 00    3.00000D 00    3.40000D 05    2.00000D 05    0.0            0.0
 5  3  0    1.00000D 00    1.10000D 00    2.00000D 00    3.00000D D0    3.40000D 05    2.00000D 05    0.0            0.0
 6  3  0    1.00000D 00    1.10000D 00    2.00000D 00    3.00000D 00    3.40000D 05    2.00000D 05    0.0            0.0
 7  3  0    1.00000D 00    6.00000D 00    1.00000D 01    2.10000D 01    6.00000D 04    4.80000D 04    0.0            0.0
 8  3  0    1.00000D 00    6.00000D 00    1.00000D 01    2.10000D 01    6.80000D 04    4.80000D 04    0.0            0.0
 9  3  0    1.00000D 00    1.10000D 00    2.00000D 00    3.00000D 00    3.000000 05    3.00000D 04    0.0            0.0
10  3  0    1.00000D 00    1.10000D 00    2.00000D 00    3.00000D 00    3.00000D 05    3.00000D 04    0.0            0.0
11  3  0    1.00000D 00    1.50000D 00    2.00000D 00    7.00000D 00    3.30000D 05    3.30000D 05    0.0            0.0
12  3  0    1.00000D 00    1.50000D 00    2.00000D 00    7.00000D 00    3.30000D 05    3.30000D 05    0.0            0.0
13  3  0    1.00000D 00    1.50000D 00    2.00000D 00    7.000D0D 00    3.30000D 05    3.30000D 05    0.0            0.0
14  3  0    1.00000D 00    1.50000D 00    2.00000D 00    7.00000D 00    3.30000D 05    3.30000D 05    0.0            0.0
15  3  0    1.00000D 00    1.50000D 00    2.00000D 00    7.00000D 00    3.30000D 05    3.30000D 05    0.0            0.0
16  3  0    1.00000D 00    8.00000D 00    9.00000D 00    1.60000D 01    1.00000D 04    3.00000D 04    0.0            0.0
17  3  0    1.00000D 00    8.00000D 00    9.00000D 00    1.60000D 01    1.00000D 04    3.00000D 04    0.0            0.0
18  3  0    2.00000D 00    2.00100D 00    8.05000D 00    8.05100D 00    6.22000D 04    2.94700D 05    2.00000D-02    1.57325D 01
19  3  0    2.00000D 00    2.00100D 00    5.75000D 00    5.75100D 00    1.61500D 04    5.15000D 04    2.000000-02    2.82099D 00

MATERIAL PROPERTIES

MATERIAL     MODULUS OF          MODULUS OF          TENSION          COMPRESS.           SHEAR
  NO.        ELASTICITY           RIGIDITY           STRESS             STRESS           STRESS

   1         3.0000D 07          1.1000D 07           75000.            75000.            37500.
   2         3.0000D 07          1.1000D 07          205000.           205000.            80000.
   3         2.8000D 07          1.2500D 07           70000.            46000.            36000.
   4         1.0500D 07          4.0000D 06           47000.            39000.            22000.
   5         1.0000D 07          3.8000D 06           35000.            34000.            17000.
   6         1.0000D 07          3.8000D 06           16000.            16000.            17000.
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 4 OF 16)

```
       7          1.0000D 06          4.0000D 05          16000.           16000.           17000.
       8          1.0000D 06          0.0                 16000.           16000.           17000.
       9          1.0000D 06          4.0000D 05          16000.           16000.           17000.
      10          1.0000D 06          4.0000D 05          16000.           16000.           17000.

INTERNAL BEAM DATA


                                                          DISTANCES FROM NEUTRAL                                  M
                                                          AXIS TO EXTREME FIBRES TORSION                 DAMPING  T
     BEAM        AREA        MOMENTS OF INERTIA            ZBIJ AXIS YBIJ AXIS PARAMETER  LENGTH         RATIO    L P-CODES   V BEAM
                                                                                                                    Y Z Y Z   B  NO.
IJ  I  J  M  N   A            IYY          IZZ          JX          Z1           Z2           XIQ         XLB          CBAR     MC I I J J  M  IJ
 1  1  2  0  0 3.200D 01 6.200D 04 3.700D 04 9.900D 04 9.600D 01 9.600D 01 0.0         1.010D 02 5.0000-02 5 0 0 1 1  0   1
 2  2  3  0  0 3.600D 01 7.700D 04 4.300D 04 1.200D 05 9.900D 01 9.900D 01 0.0         1.603D 02 5.000D-02 5 0 0 1 1  0   2
 3  3  4  0  0 3.600D 01 8.600D 04 4.300D 04 1.290D 05 5.6000 01 5.600D 01 0.0         1.600D 02 5.0000-02 5 0 0 1 1  0   3
 4  4  5  0  0 5.900D 01 1.360D 05 4.650D 04 1.825D 05 5.600D 01 5.600D 01 0.0         2.001D 02 5.000D-02 5 0 0 1 1  0   4
 5  5  6  0  0 5.900D 01 1.160D 05 4.650D 04 1.625D 05 6.600D 01 6.600D 01 0.0         1.4050 02 5.000D-02 5 0 0 1 1  0   5
 6  6  7  0  0 5.700D 01 1.360D 05 5.7000 04 1.930D 05 8.8000 01 8.800D 01 0.0         8.012D 01 5.0000-02 5 0 0 1 1  0   6
 7  7  8  0  0 4.800D 01 1.140D 05 6.200D 04 1.760D 05 9.1000 01 9.100D 01 0.0         1.609D 02 5.000D-02 5 0 0 1 1  0   7
 8  8  9  0  0 3.700D 01 5.600D 04 3.350D 04 8.950D 04 5.100D 01 5.100D 01 0.0         1.6360 02 5.0000-02 5 0 0 1 1  0   8
 9  9 10  0  0 2.500D 01 9.000D 04 9.5000 03 9.950D 04 5.000D 01 5.000D 01 0.0         2.143D 02 5.0000-02 5 0 0 0 0  0   9
10  5 11  0  1 5.400D 01 1.590D 04 1.140D 05 4.800D 04 1.000D 00 1.000D 00 0.0         1.2770 02 5.000D-02 5 0 0 0 0  0  10
11 11 12  1  0 6.320D 01 1.140D 04 1.0200 05 2.600D 04 1.0000 00 1.000D 00 0.0         1.732D 02 5.0000-02 5 0 0 0 0  0  11
12 12 13  0  0 5.630D 01 4.700D 03 5.800D 04 1.000D 04 1.000D 00 1.000D 00 0.0         1.840D 02 5.000D-02 5 0 0 0 0  0  12
13 13 14  0  0 4.070D 01 2.000D 03 2.100D 04 4.800D 03 1.000D 00 1.0000 00 0.0         1.853D 02 5.0000-02 5 0 0 0 0  0  13
14 14 15  0  1 2.000D 01 1.200D 03 8.0000 03 2.700D 03 1.000D 00 1.000D 00 0.0         1.883D 02 5.000D-02 5 0 0 0 0  0  14
15 12 16  1  1 8.000D 00 7.320D 02 1.000D 02 2.208D 02 1.000D 00 1.000D 00 0.0         7.610D 01 5.000D-02 4 0 0 0 0  0  15
16 14 17  1  1 8.000D 00 7.320D 02 1.000D 02 2.208D 02 1.000D 00 1.0000 00 0.0         7.610D D1 5.000D-02 4 0 0 0 0  0  16
17 11 18  2  0 1.000D-02 2.390D 02 2.390D 02 1.500D 02 1.000D 00 1.000D 00 0.0         8.911D 01 5.0000-02 1 0 0 0 0  1  17
18 11 18  3  0 1.000D-02 2.390D 02 2.3900 02 1.500D 02 1.000D 00 1.000D 00 0.0         8.9110 01 5.000D-02 1 0 0 0 0  1  18
19  2 19  1  0 1.000D-02 3.250D 01 3.250D 01 5.000D 00 1.000D 00 1.000D 00 0.0         6.257D 01 5.0000-02 1 0 0 0 0  1  19
20  6 12  0  D 4.070D 01 2.000D 03 2.1000 04 4.800D 03 1.000D 00 1.000D 00 0.0         2.925D 02 5.000D-02 5 0 0 1 1  0  20
21  9 14  0  0 4.070D 01 2.000D 03 2.100D 04 4.800D 03 1.000D 00 1.0000 00 0.0         6.628D 02 5.0000-02 5 0 1 0 1  0  21
22 12  0  0  0 4.070D 01 2.000D 03 2.1000 04 4.800D 03 1.000D 00 1.000D 00 0.0         5.435D 02 5.000D-02 5 0 0 0 0  0  22
23  2 20  0  0 2.036D-01 1.000D 00 1.000D 00 1.000D 00 1.000D 00 1.000D 00 0.0         1.990D 01 3.161D-01 9 0 0 0 0  1  23
24  2 21  0  0 1.309D-01 1.000D 00 1.000D 00 1.000D 00 1.000D 00 1.0000 00 0.0         2.000D 01 2.318D-0110 0 0 0 0  1  24
25 15 16  0  0 2.000D 01 0.0       0.0       0.0       1.000D 00 1.000D 00 0.0         5.816D 02 5.000D-02 5 0 0 0 0  0  25
26 15 16  2  2 2.000D 01 0.0       0.0       0.0       1.000D 00 1.000D 00 0.0         5.816D 02 5.0000-02 5 0 0 0 0  0  26
27 15  0  0  0 2.000D 01 1.200D 03 8.000D 03 2.700D 03 1.000D 00 1.000D 00 0.0         1.480D 03 5.000D-02 5 0 0 0 0  0  27
28 15  0  2  0 2.000D 01 1.200D 03 8.0000 03 2.700D 03 1.000D 00 1.000D 00 0.0         1.480D 03 5.000D-02 5 0 0 0 0  0  28


UNSYMMETRICAL BEAM DATA

                  TENSION-
                 COMPRESSION
    BEAM            FLAG      DEADBAND

IJ  I  J  M  N      IJUB         DB
25 15 16  0  0        1       8.000D-02
26 15 16  2  2       -1       8.000D-02
27 15  D  0  0        1       3.000D-01
28 15  0  2  0       -1       3.000D-01


PLASTIC HINGE AND ENO-FIXITY DATA

    BEAM        P-CODES             SHAPE FACTORS                           PLASTIC HINGE MOMENTS
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 5 OF 16)

```
 IJ  I  J  M  N IYIZJYJZ   SF35     SF26     SF35J    SF26J    PLM35        PLM26        PLM35J       PLM26J
  1  1  2  D  0  0 0 1 1   0.0      0.0      0.009    1.150    0.0          0.0          1.989D 05    1.551D 07
  2  2  3  0  0  0 0 1 1   0.0      0.0      1.250    1.250    0.0          0.0          3.403D 07    1.900D 07
  3  3  4  0  0  0 0 1 1   0.0      0.0      1.100    1.100    0.0          0.0          5.912D 07    2.956D 07
  4  4  5  0  0  0 0 1 1   0.0      0.0      1.150    1.150    0.0          0.0          9.775D 07    3.342D 07
  5  5  6  0  0  0 0 1 1   0.0      0.0      1.250    1.250    0.0          0.0          7.689D 07    3.0820 07
  6  6  7  0  0  0 0 1 1   0.0      0.0      1.250    1.250    0.0          0.0          6.7610 07    2.8340 07
  7  7  8  0  0  0 0 1 1   0.0      0.0      1.150    1.150    0.0          0.0          5.042D 07    2.742D 07
  8  8  9  0  0  0 0 1 1   0.0      0.0      1.000    1.000    0.0          0.0          3.843D 07    2.299D 07
 20  6 12  0  0  0 0 1 1   0.0      0.0      0.0      0.0      0.0          0.0          0.0          0.0
 21  9 14  0  0  0 1 0 1   0.0      0.0      0.0      0.0      0.0          0.0          0.0          0.0


OLEO STRUT BEAM DATA


                  BEAM AIR CURVE PARAMETERS

 IJ  I  J  M  N     EOLEO       FAO       FAA      EXPOLE     YMAX
 17 11 18  2  0    2.098D 01 1.086D 04 7.390D 02 1.400D 00 2.000D 01
 19  2 19  1  0    1.697D 01 3.420D 03 2.890D 02 1.400D 00 1.600D 01

                  BEAM DAMPING CONSTANTS,COULOMB FRICTION AND LINEAR SPRINGS (EXTENSION&COMPRESSION)

 IJ  I  J  M  N      BOLEO    BROLEO      XKEXT     XKCOMP     FCOUL    MPTAB
 17 11 18  2  0    4.000D 00 0.0       1.000D 05 1.000D 05 5.000D 03      1
 19  2 19  1  0    3.400D 00 0.0       5.000D 04 5.000D 04 5.000D 02      0

         OLEO METERING PIN TABLES

    TABLE NO. 1

      YOLEO          BH
  -2.00000D-01   3.52700D 02
  -9.64000D-02   3.52700D 02
  -3.76000D-02   1.02400D 01
   1.24000D-01   2.36200D 01
   3.41000D-01   2.22100D 01
   6.07000D-01   1.79000D 01
   9.53000D-01   8.24000D 00
   1.46000D 00   3.38000D 00
   2.17000D 00   2.13000D 00
   3.07000D 00   1.25000D 00
   4.13000D 00   1.56000D 00
   5.21000D 0D   1.79000D 00
   6.20000D 00   2.46000D 00
   7.05000D 00   3.58000D 00
   7.72000D 00   6.260000 00
   8.20000D 00   1.34700D 01
   8.53000D 00   3.150000 01
   8.74000D 00   6.24000D 01
   8.91000D 00   6.40600D 01
   9.12000D 00   3.42200D 01
   9.41000D 00   1.60300D 01
   9.83000D 00   8.42000D 00
   1.03900D 01   5.24000D 00
   1.10800D 01   3.68000D 00
   1.18700D 01   2.93000D 00
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 6 OF 16)

```
    1.27100D 01    2.77000D 00
    1.35400D 01    3.38000D 00
    1.42700D 01    4.93000D 00
    1.48300D 01    9.33000D 00
    1.52100D 01    2.55300D 01
    1.54000D 01    1.53790D 02
    1.54518D 01    1.00000D 03
    1.54539D 01    1.00000D 03
    1.54581D 01    1.00000D 03
    1.54940D 01    4.03850D 02
    1.56100D 01    6.77000D 01
    1.58400D 01    2.21500D 01
    1.61800D 01    9.93000D 00
    1.66500D 01    5.31000D 00
    1.72100D 01    3.02000D 00
    1.78200D 01    2.07000D 00
    1.83900D 01    9.20000D-01
    1.88200D 01    0.0
    1.89700D 01    1.00000D 01
    2.20000D 01    1.00000D 01


NONLINEAR BEAM DATA


                                                  STANOARD       LINEAR        BOTTOMING
                 BEAM                 OIRECTION   TABLE NO.     OEFLECTION     OEFLECTION

    IJ    I    J    M    N              L            NP            LOP            LDP1
    18   11   18    3    0              1             7         2.00000E 00    0.0

KR TABLE FOR I,J,M,N,L =    11   18    3    0    1
   1     0.0              1.00000E 00
   2     2.00000E 00      1.00000E 00
   3     2.00200E 00     -5.00000E-01
   4     6.00000E 00     -5.00000E-01
   5     6.00200E 00      0.0
   6     2.00000E 01      0.0
   7     4.00000E 01      0.0

DRI ELEMENTS

 I  J
 2 21

NON-STANDARD MAXIMUM POS & NEG FORCES
                                        MAXIMUM      FORCES
   BEAM                                   FMAX(IJ,L) L=
 IJ  I  J  M  N     1           2           3           4           5           6

  1  1  2  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                  0.0         0.0         0.0         0.0         0.0         0.0
  2  2  3  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                  0.0         0.0         0.0         0.0         0.0         0.0
  3  3  4  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                  0.0         0.0         0.0         0.0         0.0         0.0
  4  4  5  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                  0.0         0.0         0.0         0.0         0.0         0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 7 OF 16)

```
 5  5  6  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
 6  6  7  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
 7  7  8  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
 8  8  9  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
 9  9 10  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
10  5 11  0  1  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
11 11 12  1  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
12 12 13  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
13 13 14  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
14 14 15  0  1  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
15 12 16  1  1  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
16 14 17  1  1  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
17 11 18  2  0  4.28000 05  0.0         0.0         0.0         0.0         0.0
                4.28000 05  0.0         0.0         0.0         0.0         0.0
18 11 18  3  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
19  2 19  1  0  1.3000D 05  0.0         7.8000D 04  0.0         0.0         0.0
                1.3000D 05  0.0         7.8000D 04  0.0         0.0         0.0
20  6 12  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
21  9 14  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
22 12  0  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
23  2 20  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
24  2 21  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
25 15 16  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
26 15 16  2  2  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
27 15  0  0  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0
28 15  0  2  0  0.0         0.0         0.0         0.0         0.0         0.0
                0.0         0.0         0.0         0.0         0.0         0.0

LOAD INTERACTION CURVE SIGN CONVENTION VECTORS

SIGN           CALAC LOAD NUMBER AND SIGN
CONVENTION     FOR USER LOAO NUMBER =
NUMBER          1   2   3   4   5   6

   1            1   2  -3   4   5   6

LOAD INTERACTION CURVE DATA
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 8 OF 16)

```
CURVE BEAM LOAD NUMBER FOR   NO. OF SLOPING     SIGN CONVEN-        INTERACTION CURVE LOCATION          RUPTURE
 NO.   NO.  X AXIS  Y AXIS  INTERACTION LINES  TION NUMBER          FS           BL           WL         RATIO

  1     1      3       5           4                0            300.0000      0.0          0.0      1000.0000
  2     2      3       5           4                0            300.0000      0.0          0.0      1000.0000
  3     2      3       5           8                0            400.0000      0.0          0.0      1000.0000
  4     3      3       5           8                0            480.0000      0.0          0.0      1000.0000
  5     3      3       5           8                0            540.0000      0.0          0.0      1000.0000
  6     3      3       5           8                0            620.0000      0.0          0.0      1000.0000
  7     4      3       5           8                0            620.0000      0.0          0.0      1000.0000
  8     5      3       5           6                1            960.0000      0.0          0.0      1000.0000
  9     6      3       5           6                1            960.0000      0.0          0.0      1000.0000
 10     6      3       5           8                1           1000.0000      0.0          0.0      1000.0000
 11     7      3       5          10                1           1080.0000      0.0          0.0      1000.0000
 12     7      3       5          10                1           1160.0000      0.0          0.0      1000.0000
 13     8      3       5          10                1           1240.0000      0.0          0.0      1000.0000
 14     8      3       5           6                1           1320.0000      0.0          0.0      1000.0000
 15     9      3       5          10                1           1400.0000      0.0          0.0      1000.0000

 CURVE                   MAXIMUM LOAD CUTOFFS:                    LOAD LINE INTERCEPTS      LOAD LINE
  NO.       +X AXIS     +Y AXIS      -X AXIS      -Y AXIS        X AXIS       Y AXIS        NUMBER

  1       1.6600D 05  2.0800D 07 -1.6600D 05 -2.0800D 07  1.9900D 05  4.5600D 07        1
                                                           1.9900D 05 -4.5600D 07        2
                                                          -1.9900D 05  4.5600D 07        3
                                                          -1.9900D 05 -4.5600D 07        4
  2       1.6600D 05  2.0800D 07 -1.6600D 05 -2.0800D 07  1.9900D 05  4.5600D 07        1
                                                           1.9900D 05 -4.5600D 07        2
                                                          -1.9900D 05  4.5600D 07        3
                                                          -1.9900D 05 -4.5600D 07        4
  3       2.1000D 05  2.3800D 07 -2.1000D 05 -2.3800D 07  1.8500D 05  6.0800D 07        1
                                                           6.7430D 05  2.5400D 07        2
                                                           1.8500D 05 -6.0800D 07        3
                                                          -1.8500D 05  6.0800D 07        4
                                                          -1.8500D 05 -6.0800D 07        5
                                                           6.7430D 05 -2.5400D 07        6
                                                          -6.7430D 05  2.5400D 07        7
                                                          -6.7430D 05 -2.5400D 07        8
  4       1.0000D 20  1.0000D 20  1.0000D 20  1.0000D 20  1.9500D 05  1.3030D 08        1
                                                           5.4530D 05  2.8900D 07        2
                                                           1.9500D 05 -1.3030D 08        3
                                                          -1.9500D 05  1.3030D 08        4
                                                          -1.9500D 05 -1.3030D 08        5
                                                           5.4530D 05 -2.8900D 07        6
                                                          -5.4530D 05  2.8900D 07        7
                                                          -5.4530D 05 -2.8900D 07        8
  5       1.0000D 20  1.0000D 20  1.0000D 20  1.0000D 20  1.9900D 05  1.3730D 08        1
                                                           1.3654D 06  3.5300D 07        2
                                                           1.9900D 05 -1.3730D 08        3
                                                          -1.9900D 05  1.3730D 08        4
                                                          -1.9900D 05 -1.3730D 08        5
                                                           1.3654D 06 -3.5300D 07        6
                                                          -1.3654D 06  3.5300D 07        7
                                                          -1.3654D 06 -3.5300D 07        8
  6       2.7400D 05  4.5000D 07 -2.7400D 05 -4.5000D 07  2.8600D 05  1.8560D 08        1
                                                           3.8440D 05  7.9700D 07        2
                                                           2.8600D 05 -1.8560D 08        3
                                                          -2.8600D 05  1.8560D 08        4
                                                          -2.8600D 05 -1.8560D 08        5
                                                           3.8440D 05 -7.9700D 07        6
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 9 OF 16)

```
                                                        -3.8440D 05  7.9700D 07        7
                                                        -3.8440D 05 -7.9700D 07        8
 7       2.7400D 05  4.5000D 07 -2.7400D 05 -4.5000D 07  2.8600D 05  1.8560D 08        1
                                                         3.8440D 05  7.9700D 07        2
                                                         2.8600D 05 -1.8560D 08        3
                                                        -2.8600D 05  1.8560D 08        4
                                                        -2.8600D 05 -1.8560D 08        5
                                                         3.8440D 05 -7.9700D 07        6
                                                        -3.8440D 05  7.9700D 07        7
                                                        -3.8440D 05 -7.9700D 07        8
 8       2.8800D 05  1.0000D 20 -2.8800D 05  1.0000D 20 -5.2317D 06  7.1500D 07        1
                                                         4.7450D 05  1.5280D 08        2
                                                        -5.2317D 06 -7.1500D 07        3
                                                         4.7450D 05 -1.5280D 08        4
                                                        -4.7450D 05  1.5280D 08        5
                                                        -4.74500 05 -1.5280D 08        6
 9       2.8800D 05  1.0000D 20 -2.8800D 05  1.0000D 20 -5.2317D 06  7.1500D 07        1
                                                         4.7450D 05  1.5280D 08        2
                                                        -5.2317D 06 -7.1500D 07        3
                                                         4.7450D 05 -1.5280D 08        4
                                                        -4.7450D 05  1.5280D 08        5
                                                        -4.7450D 05 -1.5280D 08        6
10       2.5400D 05  7.4000D 07 -2.5400D 05 -7.4000D 07  3.0100D 05  2.2870D 08        1
                                                         1.3581D 06  8.4200D 07        2
                                                         3.0100D 05 -2.2870D 08        3
                                                        -3.0100D 05  2.2870D 08        4
                                                        -3.0100D 05 -2.2870D 08        5
                                                         1.3581D 06 -8.4200D 07        6
                                                        -1.3581D 06  8.4200D 07        7
                                                        -1.3581D 06 -8.4200D 07        8
11       1.0000D 20  1.0000D 20  1.00D00 20  1.0000D 20  2.1D00D 05 -5.5588D 08        1
                                                         3.2770D 05  1.0775D 08        2
                                                         1.5738D 06  6.4000D 07        3
                                                        -2.1000D 05 -5.5588D 08        4
                                                         3.2770D 05 -1.0775D 08        5
                                                        -3.2770D 05  1.0775D 08        6
                                                        -3.2770D 05 -1.0775D 08        7
                                                         1.5738D 06 -6.4000D 07        8
                                                        -1.5738D 06  6.4000D 07        9
                                                        -1.5738D 06 -6.4000D 07       10
12       1.0000D 20  1.D000D 20  1.0000D 20  1.0000D 20  2.3900D 05 -2.6564D 08        1
                                                         3.7221D 05  8.3500D 07        2
                                                         8.0484D 05  4.9900D 07        3
                                                        -2.390DD 05 -2.6564D 08        4
                                                         3.7221D 05 -8.3500D 07        5
                                                        -3.7221D 05  8.3500D 07        6
                                                        -3.7221D 05 -8.3500D 07        7
                                                         8.0484D 05 -4.9900D 07        8
                                                        -8.0484D 05  4.9900D 07        9
                                                        -8.0484D 05 -4.9900D 07       10
13       1.0000D 20  3.5000D 07  1.0000D 20 -3.5000D 07  1.9800D 05 -2.1732D 08        1
                                                         4.0946D 05  5.0500D 07        2
                                                         9.6522D 05  3.7000D 07        3
                                                        -1.9800D 05 -2.1732D 08        4
                                                         4.0946D 05 -5.0500D 07        5
                                                        -4.0946D 05  5.0500D 07        6
                                                        -4.0946D 05 -5.0500D 07        7
                                                         9.6522D 05 -3.7000D 07        8
                                                        -9.6522D 05  3.7000D 07        9
                                                        -9.6522D 05 -3.7000D 07       10
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 10 OF 16)

```
  14       1.0000D 20  2.7200D 07  1.00000 20 -2.7200D 07  1.4800D 05 -9.1818D 07       1
                                                           6.6250D 05  3.1800D 07       2
                                                          -1.4800D 05 -9.1818D 07       3
                                                           6.6250D 05 -3.1800D 07       4
                                                          -6.6250D 05  3.1800D 07       5
                                                          -6.6250D 05 -3.1800D 07       6
  15       1.0000D 20  1.0000D 20  1.0000D 20  1.0000D 20  1.2350D 05 -5.4998D 07       1
                                                           3.5072D 05  2.4200D 07       2
                                                           9.1452D 05  1.8900D 07       3
                                                          -1.2350D 05 -5.4998D 07       4
                                                           3.5072D 05 -2.4200D 07       5
                                                          -3.5072D 05  2.4200D 07       6
                                                          -3.5072D 05 -2.4200D 07       7
                                                           9.1452D 05 -1.8900D 07       8
                                                          -9.1452D 05  1.8900D 07       9
                                                          -9.1452D 05 -1.8900D 07      10


MASSES HAVING NONZERO ANGULAR MOMENTA (HE),
CROSS PRODUCTS OF INERTIA (IXY,IYZ,IXZ)
OR LIFT CONSTANTS (LC)

    I       LC          HEX          HEY          HEZ          IXY          IYZ          IXZ
   16  0.0         1.0000D 05  0.0          0.0          D.0          0.0          0.0
   17  0.0         1.0000D 05  0.0          0.0          0.0          0.0          0.0
NONZERO PHIDP,THEDP,PSIDP
        I   PHIDP          THEDP          PSIDP

         1    0.0           -2.24027D-03    0.0
         2    0.0           -2.22840D-03    0.0
         3    0.0           -2.01666D-03    0.0
         4    0.0           -1.31021D-03    0.0
         5    0.0            0.0            0.0
         6    0.0            1.90573D-03    0.0
         7    0.0            2.64616D-03    0.0
         8    0.0            3.92551D-03    0.0
         9    0.0            5.79121D-D3    0.0
        10    0.0            6.380440-03    0.0
        11    6.69274D-03   -2.20144D-03    5.60556D-04
        12    1.30603D-02   -6.67157D-03    9.32583D-04
        13    2.24127D-02   -1.03213D-02    1.68154D-03
        14    2.56270D-02   -7.39424D-03    5.29610D-03
        15    1.70994D-02   -9.06780D-03    4.92518D-03
        16   -7.48129D-02    2.48595D-02    5.43662D-02
        17   -6.24449D-02    2.36452D-02    5.91654D-02
        18    6.68924D-03   -2.20407D-03    5.60529D-04
        19    0.0           -2.22316D-03    0.0
        20    0.0           -4.13788D-03    0.0
        21    0.0           -2.22840D-03    0.0


ACCELERATION INPUT TABLE DATA

MASS LOCATION   DIRECTION   NO. PTS.   TYPE
      1             3          2         1
      2             3          2         1
      3             3          2         1
      4             3          2         1
      5             3          2         1
      6             3          2         1
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 11 OF 16)

```
      7            3          2          1
      8            3          2          1
      9            3          2          1
     10            3          2          1
     11            3          2          1
     12            3          2          1
     13            3          2          1
     14            3          2          1
     15            3          2          1
     16            3          2          1
     17            3          2          1
     18            3          2          1
     19            3          2          1
  PT       TIME            ACCEL
   1     0.0            -9.500E 01
   2     1.000E 00      -9.500E 01
   3     0.0            -6.245E 02
   4     1.000E 00      -6.245E 02
   5     0.0            -1.861E 03
   6     1.000E 00      -1.861E 03
   7     0.0            -4.715E 03
   8     1.000E 00      -4.715E 03
   9     0.0            -7.901E 03
  10     1.000E 00      -7.901E 03
  11     0.0            -1.991E 03
  12     1.000E 00      -1.991E 03
  13     0.0            -2.316E 03
  14     1.000E 00      -2.316E 03
  15     0.0            -7.854E 02
  16     1.000E 00      -7.854E 02
  17     0.0            -4.500E 02
  18     1.000E 00      -4.500E 02
  19     0.0             1.745E 04
  20     1.000E 00       1.745E 04
  21     0.0            -1.542E 04
  22     1.000E 00      -1.542E 04
  23     0.0            -2.819E 04
  24     1.000E 00      -2.819E 04
  25     0.0            -2.139E 04
  26     1.000E 00      -2.139E 04
  27     0.0            -1.782E 04
  28     1.000E 00      -1.782E 04
  29     0.0            -6.241E 03
  30     1.000E 00      -6.241E 03
  31     0.0            -2.708E 02
  32     1.000E 00      -2.708E 02
  33     0.0            -2.583E 02
  34     1.000E 00      -2.583E 02
  35     0.0             0.0
  36     1.000E 00       0.0
  37     0.0             0.0
  38     1.000E 00       0.0


I,J,M,N
 K-MATRIX FOR INTERNAL BEAM IJ
   1  2  0  0
     3.16806D 06    0.0           0.0           0.0           0.0           0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 12 OF 16)

```
  0.0            4.30838D 06    0.0            0.0            0.0           -2.17591D 08
  0.0            0.0            7.21945D 06    0.0            3.64612D 08    0.0
  0.0            0.0            0.0            3.724450 09    0.0            0.0
  0.0            0.0            3.64612D 08    0.0            2.455525D 10   0.0
  0.0           -2.17591D 08    0.0            0.0            0.0            1.46523D 10
2  3  0  0
  2.24563D 06    0.0            0.0            0.0            0.0            0.0
  0.0            1.25243D 06    0.0            0.0            0.0           -1.00390D 08
  0.0            0.0            2.242730 06    0.0            1.79768D 08    0.0
  0.0            0.0            0.0            2.84446D 09    0.0            0.0
  0.0            0.0            1.79768D 08    0.0            1.92126D 10    0.0
  0.0           -1.00390D 08    0.0            0.0            0.0            1.07291D 10
3  4  0  0
  2.24968D 06    0.0            0.0            0.0            0.0            0.0
  0.0            1.25924D 06    0.0            0.0            0.0           -1.00753D 08
  0.0            0.0            2.51847D 06    0.0            2.01506D 08    0.0
  0.0            0.0            0.0            3.06332D 09    0.0            0.0
  0.0            0.0            2.01506D 08    0.0            2.14970D 10    0.0
  0.0           -1.00753D 08    0.0            0.0            0.0            1.07485D 10
4  5  0  0
  2.94877D 06    0.0            0.0            0.0            0.0            0.0
  0.D            6.96624D 05    0.0            0.0            0.0           -6.96916D 07
  0.0            0.0            2.03744D 06    0.0            2.03829D 08    0.0
  0.0            0.0            0.0            3.46605D 09    0.0            0.0
  0.0            0.0            2.03829D 08    0.0            2.71886D 10    0.0
  0.0           -6.96916D 07    0.0            0.0            0.0            9.29611D 09
5  6  0  0
  4.19872D 06    0.0            0.0            0.0            0.0            0.0
  0.0            2.01108D 06    0.0            0.0            0.0           -1.41298D 08
  0.0            0.0            5.01689D 06    0.0            3.52484D 08    0.0
  0.0            0.0            0.0            4.39443D 09    0.0            0.0
  0.0            0.0            3.52484D 08    0.0            3.302050 10    0.0
  D.0           -1.41298D 08    0.0            0.0            0.0            1.32367D 10
6  7  0  0
  7.11440D 06    0.0            0.0            0.0            0.0            0.0
  0.0            1.32999D 07    0.0            0.0            0.0           -5.32787D 08
  0.0            0.0            3.17330D 07    0.0            1.27121D 09    0.0
  0.0            0.0            0.0            9.15386D 09    0.0            0.0
  0.0            0.0            1.27121D 09    0.0            6.78989D 10    0.0
  0.0           -5.32787D 08    0.0            0.0            0.0            2.84576D 10
7  8  0  0
  2.98318D 06    0.0            0.0            0.0            0.0            0.0
  0.0            1.78602D 06    0.0            0.0            0.0           -1.43687D 08
  0.0            0.0            3.28397D 06    0.0            2.64199D 08    0.0
  0.0            0.0            0.0            4.15656D 09    0.0            0.0
  0.0            0.0            2.64199D 08    0.0            2.83402D 10    0.0
  0.0           -1.43687D 08    0.0            0.0            0.0            1.54131D 10
8  9  0  0
  2.26109D 06    0.0            0.0            0.0            0.0            0.0
  0.0            9.17438D 05    0.0            0.0            0.0           -7.50637D 07
  0.0            0.0            1.53363D 06    0.0            1.25480D 08    0.0
  0.0            0.0            0.0            2.07837D 09    0.0            0.0
  0.0            0.0            1.25480D 08    0.0            1.36888D 10    0.0
  0.0           -7.50637D 07    0.0            0.0            0.0            8.18883D 09
9 10  0  0
  1.16655D 06    0.0            0.0            0.0            0.0            0.0
  0.0            1.15822D 05    0.D            0.0            0.0           -1.24108D 07
  0.0            0.0            1.09726D 06    0.0            1.17576D 08    0.0
  0.0            0.0            0.0            1.76428D 09    0.0            0.0
  0.0            0.0            1.17576D 08    0.0            1.67983D 1D    0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 13 OF 16)

```
    0.0          -1.24108D 07   0.0            0.0            0.0            1.77315D 09
  5 11  0  1
    4.22720D 06   0.0           0.0            0.0            0.0            0.0
    0.0           6.56240D 06   0.0            0.0            0.0           -4.19154D 08
    0.0           0.0           9.15282D 05    0.0            5.84610D 07    0.0
    0.0           0.0           0.0            1.42785D 09    0.0            0.0
    D.0           0.0           5.84610D 07    0.0            4.97870D 09    0.0
    0.0          -4.19154D 08   0.0            0.0            0.0            3.56963D 10
 11 12  1  0
    3.64899D 06   0.0           0.0            0.0            0.0            0.0
    0.0           2.35585D 06   0.0            0.0            0.0           -2.04015D 08
    0.0           0.0           2.63300D 05    0.0            2.28017D 07    0.0
    0.0           0.0           0.0            5.70443D 08    0.0            0.0
    0.0           0.0           2.28017D 07    0.0            2.63281D 09    0.0
    0.0          -2.04015D 08   0.0            0.0            0.0            2.35567D 10
 12 13  0  0
    3.06056D 06   0.0           0.0            0.0            0.0            0.0
    0.0           1.11812D 06   0.0            0.0            0.0           -1.02841D 08
    0.0           0.0           9.06063D 04    0.0            8.33365D 06    0.0
    0.0           0.0           0.0            2.06574D 08    0.0            0.0
    0.0           0.0           8.33365D 06    0.0            1.02200D 09    0.0
    0.0          -1.02841D 08   0.0            0.0            0.0            1.26119D 10
 13 14  0  0
    2.19586D 06   0.0           0.0            0.0            0.0            0.0
    0.0           3.95762D 05   0.0            0.0            0.0           -3.66769D 07
    0.0           0.0           3.76916D 04    0.0            3.49304D 06    0.0
    0.0           0.0           0.0            9.84093D 07    0.0            0.0
    0.0           0.0           3.49304D 06    0.0            4.31620D 08    0.0
    0.0          -3.66769D 07   0.0            0.0            0.0            4.53201D 09
 14 15  0  1
    1.06228D 06   0.0           0.0            0.0            0.0            0.0
    0.0           1.43848D 05   0.0            0.0            0.0           -1.35414D 07
    0.0           0.0           2.15772D 04    0.0            2.03120D 06    0.0
    0.0           0.0           0.0            5.44952D 07    0.0            0.0
    0.0           0.0           2.03120D 06    0.0            2.54948D 08    0.0
    0.0          -1.35414D 07   0.0            0.0            0.0            1.69965D 09
 12 16  1  1
    1.10385D 06   0.0           0.0            0.0            0.0            0.0
    0.0           2.85932D 04   0.0            0.0            0.0           -1.08793D 06
    0.0           0.0           2.09302D 05    0.0            7.96367D 06    0.0
    0.0           0.0           0.0            1.16062D 07    0.0            0.0
    0.0           0.0           7.96367D 06    0.0            4.04009D 08    0.0
    0.0          -1.08793D 06   0.0            0.0            0.0            5.51925D 07
 14 17  1  1
    1.10387D 06   0.0           0.0            0.0            0.0            0.0
    0.0           2.85950D 04   0.0            0.0            0.0           -1.08798D 06
    0.0           0.0           2.09315D 05    0.0            7.96399D 06    0.0
    0.0           0.0           0.0            1.16064D 07    0.0            0.0
    0.0           0.0           7.96399D 06    0.0            4.04017D 08    0.0
    0.0          -1.08798D 06   0.0            0.0            0.0            5.51936D 07
 11 18  2  0
    3.36651D 03   0.0           0.0            0.0            0.0            0.0
    0.0           1.21584D 05   0.0            0.0            0.0           -5.41736D 06
    0.0           0.0           1.21584D 05    0.0            5.41736D 06    0.0
    0.0           0.0           0.0            1.85158D 07    0.0            0.0
    0.0           0.0           5.41736D 06    0.0            3.21838D 08    0.0
    0.0          -5.41736D 06   0.0            0.0            0.0            3.21838D 08
 11 18  3  0
    3.366510 03   0.0           0.0            0.0            0.0            0.0
    0.0           1.21584D 05   0.0            0.0            0.0           -5.41736D 06
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 14 OF 16)

```
   0.0           0.0           1.21584D 05   0.0           5.41736D 06   0.0
   0.0           0.0           0.0           1.85158D 07   0.0           0.0
   0.0           0.0           5.41736D 06   0.0           3.21838D 08   0.0
   0.0          -5.41736D 06   0.0           0.0           0.0           3.21838D 08
 2 19  1  0
   4.79488D 03   0.0           0.0           0.0           0.0           0.0
   0.0           4.77700D 04   0.0           0.0           0.0          -1.49441D 06
   0.0           0.0           4.77700D 04   0.0           1.49441D 06   0.0
   0.0           0.0           0.0           8.79061D 05   0.0           0.0
   0.0           0.0           1.49441D 06   0.0           6.23334D 07   0.0
   0.0          -1.49441D 06   0.0           0.0           0.0           6.23334D 07
 6 12  0  0
   1.39154D 06   0.0           0.0           0.0           0.0           0.0
   0.0           1.00717D 05   0.0           0.0           0.0          -1.47290D 07
   0.0           0.0           9.59211D 03   0.0           1.40276D 06   0.0
   0.0           0.0           0.0           6.23628D 07   0.0           0.0
   0.0           0.0           1.40276D 06   0.0           2.73521D 08   0.0
   0.0          -1.47290D 07   0.0           0.0           0.0           2.87197D 09
 9 14  0  0
   6.14019D 05   0.0           0.0           0.0           0.0           0.0
   0.0           8.65292D 03   0.0           0.0           0.0          -2.86778D 06
   0.0           0.0           8.24088D 02   0.0           2.73122D 05   0.0
   0.0           0.0           0.0           2.75177D 07   0.0           0.0
   0.0           0.0           2.73122D 05   0.0           1.20692D 08   0.0
   0.0          -2.86778D 06   0.0           0.0           0.0           1.26726D 09
12  0  0  0
   7.48826D 05   0.0           0.0           0.0           0.0           0.0
   0.0           1.56950D 04   0.0           0.0           0.0          -4.26524D 06
   0.0           0.0           1.49476D 03   0.0           4.06214D 05   0.0
   0.0           0.0           0.0           3.35592D 07   0.0           0.0
   0.0           0.0           4.06214D 05   0.0           1.47189D 08   0.0
   0.0          -4.26524D 06   0.0           0.0           0.0           1.54549D 09
 2 20  0  0
   1.02276D 04   0.0           0.0           0.0           0.0           0.0
   0.0           1.52161D 03   0.0           0.0           0.0          -1.51437D 04
   0.0           0.0           1.52161D 03   0.0           1.51437D 04   0.0
   0.0           0.0           0.0           2.00956D 04   0.0           0.0
   0.0           0.0           1.51437D 04   0.0           2.00956D 05   0.0
   0.0          -1.51437D 04   0.0           0.0           0.0           2.00956D 05
 2 21  0  0
   6.54560D 03   0.0           0.0           0.0           0.0           0.0
   0.0           1.50001D 03   0.0           0.0           0.0          -1.50001D 04
   0.0           0.0           1.50001D 03   0.0           1.50001D 04   0.0
   0.0           0.0           0.0           2.000D0D 04   0.0           0.0
   0.0           0.0           1.50001D 04   0.0           2.00000D 05   0.0
   0.0          -1.50001D 04   0.0           0.0           0.0           2.00000D 05
15 16  0  0
   3.438830 05   0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
15 16  2  2
   3.43883D 05   0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           D.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
   0.0           0.0           0.0           0.0           0.0           0.0
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 15 OF 16)

```
15  0  0  0
   1.35105D 05    0.0            0.0            0.0            0.0            0.0
   0.0            2.95934D 02    0.0            0.0            0.0           -2.19040D 05
   0.0            0.0            4.43900D 01    0.0            3.28560D 04    0.0
   0.0            0.0            0.0            6.93088D 06    0.0            0.0
   0.0            0.0            3.28560D 04    0.0            3.24252D 07    0.0
   0.0           -2.19040D 05    0.0            0.0            0.0            2.16168D 08
15  0  2  0
   1.35105D 05    0.0            0.0            0.0            0.0            0.0
   0.0            2.95934D 02    0.0            0.0            0.0           -2.19040D 05
   0.0            0.0            4.43900D 01    0.0            3.28560D 04    0.0
   0.0            0.0            0.0            6.93088D 06    0.0            0.0
   0.0            0.0            3.28560D 04    0.0            3.24252D 07    0.0
   0.0           -2.19040D 05    0.0            0.0            0.0            2.16168D 08
```

FIGURE 2-9. FORMATTED PRINTOUT OF INPUT DATA (SHEET 16 OF 16)

- Nonzero mass orientation Euler angles (optional) (When a static deflection data set XYZ.NASOUT.DATA is read in, all masses will be rotated and a complete printout of this section of data will occur.)
- Acceleration input table data (optional)
- $\left[K_{ij}\right]$ matrices for all NB internal beams

The nonlinear beam data section prints out all the KR tables, whether these are user-input or standard tables coded into KRASH85. Similarly, the 6 x 6 linear stiffness matrix $\left[K_{ij}\right]$ is printed for all NB internal beam elements, whether $\left[K_{ij}\right]$ is directly input by the user or internally calculated in KRASH. The printed matrix corresponds to the lower right-hand quandrant of a full 12 by 12 beam stiffness matrix (figure 1-19, Vol. 1).

Certain items in this formatted printout of the input data provide additional information not directly input by the user. These include the following:

- External spring data - The actual damping constant used in the KRASH85 calculations of spring damping force is shown (CDAMP(IKM)).
- Internal beam data - Beam lengths are shown (XLB). The item called VBM is a flag denoting which, if any, of the beams the program treats as vertical beams. VBM = 1 corresponds to a vertical beam, and VBM = 0 corresponds to a normal beam. The interpretation of the beam orientation Euler angles, part of the time-history beam deflection output, depends upon whether a normal or vertical beam is noted.
- Plastic hinge and end-fixity data - The actual plastic hinge moments, calculated within the program, are output. (PLM35,...,PLM26J)
- Mass data - The coordinates for the mass and node points are not equal to those input by the user in XYZ.DATA. The input coordinates have been modified by the initial mass and node point deflections, also shown in the formatted output of the input data. All calculations in KRASH85 use the modified coordinate data.

2.3.1.3 Miscellaneous Calculated Data

The miscellaneous calculated data are illustrated in figure 2-10, and is described in the following subsections.

2.3.1.3.1 Model Parameters. - The overall vehicle weight, c.g. position, and inertias are shown. These are used to see how well the anlytical model matches the actual vehicle being analyzed. This output is always for a complete airplane, even if only a half-airplane model is input (RUMMOD = 1.0). The initial position of the vehicle c.g., relative to the ground, is also shown.

2.3.1.3.2 Beam Loads and Deflections Corresponding to Yielding. - This output is generated only if NIC on card 50 (figure 2-3) is input nonzero. The beam loads and deflections corresponding to yielding are used as guidelines for establishing nonlinear deflection points for internal beam KR curves. The loads are calculated using the stress and buckling equations discussed in Volume I, Section 1.3.17, along with the appropriate yield stress for the beam material given in table 2-3 of this report.

The loads corresponding to yield stress are uncoupled loads (e.g., the shear forces are those corresonding to yielding without any bending moment applied.) Similarly, beam deflections are those resulting from the corresponding load only without the coupled load being applied. In actual loading situations, some degree of coupling is always present, so the deflections corresponding to yield provide only a rough indication of appropriate values to use for setting up KR curves. Furthermore, no attempt has been made to include in the analysis the effects of stress concentrations, geometric shape factors, and end attachment details.

2.3.1.3.3 Overall Vehicle Forces/Accelerations at Time Zero. - This block of output data is printed twice. The first time shows the six net loads (pounds and inch-pounds) at the airplane c.g., and the resulting six rigid body accelerations. These c.g. accelerations are then used to calculate the rigid body acceleration at each mass point in the model. These mass point accelerations yield inertia relief loads at each mass point. If these inertia relief loads are included in the total airplane force/moment balance, the net c.g. loads and accelerations should be zero. The second printout shows that the c.g. loads/accelerations, including inertia relief, are indeed very small (less than E-16 for all accelerations). The above calculations are performed in subroutine NETFOR, the purpose of which is to calculate the net forces acting on each mass. These forces are used in the NASTRAN static load solution. Inertia relief loads are included to guarantee that a balanced set of applied loads is input to the NASTRAN model.

2.3.1.3.4 Individual Mass Forces/Accelerations At Time Zero. - Figure 2-10 also shows this list of loads and accelerations for each mass in the model. The specific data output for each mass is as follows:

Line 1: Gravity loads, c.g. axes

Line 2: External loads, c.g. axes. These are the loads due to input time histories of external loads at specified masses, per the 3500-series cards. This is the method used to input aerodynamic loads into the model for the sample case.

Line 3: Aerodynamic lift, c.g. axes. These data reflects any aerodynamic lift calculated by means of inputting LC on the 3100-series cards. This option is not used in the sample case. The aerodynamic loads calculated using the 3300-series aero data are not included in the load calculations in NETFOR. Therefore, these loads will not get into the NASTRAN model to determine the proper balanced initial conditions.

Line 4: Inertia loads, c.g. axes. The inertia loads are calculated in NETFOR, as described in Section 2.3.1.4 above, to achieve a balanced set of loads for input to NASTRAN.

Line 5: Net loads, c.g. axes. These loads are the sum of all the above loads. The net loads are the input to the NASTRAN static load solution.

Line 6: Accelerations, mass axes. These are the rigid body airplane accelerations at time zero at each mass point. As explained in Section 2.3.1.4, these accelerations are calculated from the airplane c.g. acceleration, which in turn is calculated from all the loads except inertia relief loads. The mass point accelerations in line 6 times the mass point inertia matrix yields the inertia relief loads. These accelerations are output in mass axes to facilitate comparisons with KRASH85 time-history output at time zero. The accelerations for the latter are also in mass axes. The two sets of accelerations should be equal for a properly balanced set of initial conditions.

All quantities shown in this output have the units of pounds or inch-pounds for loads, and g's or rad/sec^2 for accelerations. The sign convention is positive forward, right, and down, with right-hand moments about those axes. These data are presented basically as reference information; the user need not examine these data closely. The determination of whether or not the balanced initial conditions are acceptably accurate can be made based on data that are presented at the time zero printout from program KRASH85. (Section 2.3.3).

2.3.2 MSCTRAN Output

The output data from MSC/NASTRAN are discussed in this section. Familiarity with these output data is not necessary to successfully run program KRASH. If difficulties occur in achieving a balanced initial condition, then a review of this data may be necessary to help isolate the problem.

2.3.2.1 Executive Control Deck Echo

This is shown in figure 2-11, and consists of only four lines. These are generated automatically by program KRASHIC. SOL 24 refers to Rigid Format Solution No. 24, which is the small deflection linear static solution.

2.3.2.2 Case Control Deck Echo

This is also shown in figure 2-11, and contains only 13 cards. These are generated automatically by program KRASHIC. The output control card DISPLACEMENT (PRINT,PUNCH) = ALL, used in conjunction with the appropriate JCL cards, causes the output displacement vector to be written as data set XYZ.NASOUT.DATA in the user's library. If the user wants to eliminate or revise some of the NASTRAN output data, then Format No. 1020 in subroutine NAST, in program KRASHIC, should be revised accordingly.

2.3.2.3 Input Bulk Data Deck Echo

The complete input bulk data deck is reproduced in this echo, shown as figure 2-12. All these cards are generated automatically by program KRASHIC, in subroutines NAST and NAST10. The CONM2 (mass property), PLOTEL (plot data) and EIGR (eigenvalue) cards are not used in the static load solution employed (SOL 24). KRASHIC converts a KRASH85 input data set into a NASTRAN

```
MODEL PARAMETERS

VEHICLE WT = 1.865560D 05

VEHICLE CG POSITION
X (FS) =  8.43139D 02
Y (BL) =  0.0
Z (WL) =  2.09423D 02

VEHICLE INERTIAS (IN-LB-SEC**2)
I(XX) =  3.39292D 07
I(YY) =  3.87955D 07
I(ZZ) =  7.12554D 07
I(XY) =  0.0
I(YZ) =  0.0
I(XZ) =  1.95061D 06


VEHICLE CG INITIAL GROUND COORDINATES
XCG IS THE DISTANCE FROM SLOPE/GROUND INTERSECTION TO VEHICLE CG,+FORWARD
ZCG IS THE DISTANCE FROM GROUND PLANE TO VEHICLE CG,+DOWN
XCG =  0.0
ZCG = -1.38499D 02


BEAM LOADS


     BEAM                   AXIAL LOAD                   SHEAR FORCE                         MOMENT                   BEAM
 IJ  I  J  M  N   BUCKLING    TENSION   COMPRESSION  LATERAL(Y) VERTICAL(Z)  ROLL(X)      PITCH(Y)       YAW(Z)   IJ  I  J  M  N

  1  1  2  0  0  7.1584D 08  1.1200D 06  1.0880D 06  3.6448D 05  3.6448D 05  0.0         2.1958D 07  1.3104D 07  1  1  2  0  0
  2  2  3  0  0  3.3027D 08  1.2600D 06  1.2240D D6  4.1004D 05  4.1D04D 05  0.0         2.6444D 07  1.4768D 07  2  2  3  0  0
  3  3  4  0  0  3.3146D 08  1.2600D 06  1.224DD 06  4.1004D 05  4.1004D 05  0.0         5.2214D 07  2.6107D 07  3  3  4  0  0
  4  4  5  0  0  2.2928D 08  2.0650D 06  2.0060D 06  6.7201D 05  6.7201D 05  0.0         8.2571D 07  2.8232D 07  4  4  5  0  0
  5  5  6  0  0  4.6485D 08  2.0650D 06  2.0060D 06  6.7201D 05  6.7201D 05  0.0         5.9758D 07  2.3955D 07  5  5  6  0  0
  6  6  7  0  0  1.7528D 09  1.9950D 06  1.9380D 06  6.4923D 05  6.4923D 05  0.D         5.2545D 07  2.2023D 07  6  6  7  0  0
  7  7  8  0  0  4.7271D 08  1.6800D 06  1.6320D 06  5.4672D 05  5.4672D 05  0.0         4.2593D 07  2.3165D 07  7  7  8  0  0
  8  8  9  0  0  2.4695D 08  1.2950D 06  1.2580D 06  4.2143D D5  4.2143D 05  0.0         3.7333D 07  2.2333D 07  8  8  9  0  0
  9  9 10  0  0  8.1659D 07  8.7500D 05  8.5C00D 05  2.8475D 05  2.8475D 05  0.0         6.1200D 07  6.4600D 06  9  9 10  0  0
 10  5 11  0  1  3.8466D 08  1.8900D 06  1.8360D 06  6.1506D 05  6.1506D 05  0.0         5.4060D 08  3.8760D 09 10  5 11  0  1
 11 11 12  1  0  1.5003D 08  2.2120D 06  2.1488D 06  7.1985D 05  7.1985D 05  0.0         3.8760D 08  3.4680D 09 11 11 12  1  0
 12 12 13  0  0  5.4833D 07  1.9705D 06  1.9142D 06  6.4126D 05  6.4126D 05  0.0         1.5980D 08  1.9720D 09 12 12 13  0  0
 13 13 14  0  0  2.2983D 07  1.4245D 06  1.3838D 06  4.6357D 05  4.6357D 05  0.0         6.8000D 07  7.1400D 08 13 13 14  0  0
 14 14 15  0  1  1.3365D 07  7.0000D 05  6.8000D 05  2.2780D 05  2.2780D 05  0.0         4.0800D 07  2.7200D 08 14 14 15  0  1
 15 12 16  1  1  7.1583D 06  3.7600D 05  3.1200D 05  1.1792D 05  1.1792D 05  0.0         2.8548D 07  3.9000D 06 15 12 16  1  1
 16 14 17  1  1  7.1586D 06  3.7600D 05  3.1200D 05  1.1792D 05  1.1792D 05  0.0         2.8548D 07  3.9000D 06 16 14 17  1  1
 17 11 18  2  0  3.5645D 07  7.5000D 02  7.5000D 02  2.5125D 02  2.5125D D2  0.0         1.7925D 07  1.7925D 07 17 11 18  2  0
 18 11 18  3  0  3.5645D 07  7.5000D 02  7.5000D 02  2.5125D 02  2.5125D 02  0.0         1.7925D 07  1.79250 07 18 11 18  3  0
 19  2 19  1  0  9.8328D 06  7.5000D 02  7.5000D 02  2.5125D 02  2.5125D 02  0.0         2.4375D 06  2.4375D 06 19  2 19  1  0
 20  6 12  0  0  4.6149D 06  1.4245D 06  1.3838D 06  4.6357D 05  4.6357D 05  0.0         6.8000D 07  7.1400D 08 20  6 12  0  0
 21  9 14  0  0  1.7971D 06  1.4245D 06  1.3838D 06  0.0         4.6357D D5  D.0         6.8000D 07  0.0        21  9 14  0  0
 22 12  0  0  0  2.6728D 06  1.4245D 06  1.3838D 06  4.6357D 05  4.6357D 05  0.0         6.8000D 07  7.14D0D 08 22 12  0  0  0
 23  2 20  0  0  9.9642D D4  3.2573D 03  3.2573D 03  2.3188D 03  2.3188D 03  0.0         1.6000D 04  1.6000D 04 23  2 20  0  0
 24  2 21  0  0  9.8697D 04  2.0946D 03  2.0946D 03  1.4911D 03  1.4911D 03  0.0         1.6000D 04  1.6000D 04 24  2 21  0  0
 25 15 16  0  0  0.0         7.0000D 05  6.8000D 05  2.2780D 05  2.2780D 05  0.0         0.0         0.0        25 15 16  0  0
 26 15 16  2  2  0.0         7.0000D 05  6.8000D 05  2.2780D 05  2.2780D 05  0.0         0.0         0.0        26 15 16  2  2
 27 15  0  0  0  2.1618D 05  7.0000D 05  6.8DDDD 05  2.2780D D5  2.2780D 05  0.0         4.08D0D 07  2.7200D 08 27 15  0  0  0
 28 15  0  2  0  2.1618D 05  7.0000D 05  6.8000D 05  2.2780D 05  2.2780D 05  0.0         4.0800D 07  2.7200D 08 28 15  0  2  0
```

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 5)

```
BEAM DEFLECTIONS

     BEAM                    DEFLECTION                                 TRANSLATION DUE TO                                ROTATION ABOUT
 IJ  I  J  M  N  BUCKLING    TENSION  COMPRESSION  F(Y)        F(Z)       BM(Z)      BM(Y)      X-AXIS       Y-AXIS     Z-AXIS

  1  1  2  0  0  2.26DD 02  3.535D-01  3.434D-01  8.460D-02  5.049D-02  1.204D-01  1.204D-01  0.0          3.577D-03  3.577D-03
  2  2  3  0  0  1.471D 02  5.611D-01  5.451D-01  3.274D-01  1.828D-01  2.942D-01  2.942D-01  0.0          5.506D-03  5.506D-03
  3  3  4  0  0  1.473D 02  5.601D-01  5.441D-D1  3.256D-01  1.628D-01  5.182D-01  5.182D-01  0.0          9.716D-03  9.716D-03
  4  4  5  0  0  7.775D 01  7.003D-01  6.803D-01  9.647D-01  3.298D-01  8.102D-01  8.102D-01  0.0          1.2150-02  1.215D-02
  5  5  6  0  0  1.107D 02  4.918D-01  4.778D-01  3.342D-01  1.3390-01  3.391D-01  3.391D-01  0.0          7.239D-03  7.239D-03
  6  6  7  0  0  2.464D 02  2.804D-01  2.724D-01  4.881D-02  2.046D-02  8.267D-02  8.267D-02  0.0          3.096D-03  3.096D-03
  7  7  8  0  0  1.585D 02  5.632D-01  5.471D-01  3.061D-01  1.665D-01  3.224D-01  3.224D-01  0.0          6.012D-03  6.012D-03
  8  8  9  0  0  1.092D 02  5.727D-01  5.564D-01  4.594D-01  2.748D-01  5.951D-01  5.951D-01  0.0          1.091D-02  1.091D-02
  9  9 10  0  0  7.000D 01  7.501D-01  7.286D-01  2.459D 00  2.595D-01  1.041D D0  1.041D 00  0.0          1.457D-02  1.457D-02
 10  5 11  0  1  9.100D 01  4.471D-01  4.343D-01  9.372D-02  6.720D-01  1.849D 01  1.849D 01  0.0          4.343D-01  4.343D-01
 11 11 12  1  0  4.112D 01  6.062D-01  5.889D-01  3.056D-01  2.734D 00  3.400D 01  3.400D 01  0.0          5.889D-01  5.889D-01
 12 12 13  0  0  1.7920 01  6.438D-01  6.254D-01  5.735D-01  7.077D 00  3.835D 01  3.835D 01  0.0          6.254D-01  6.254D-01
 13 13 14  0  0  1.047D 01  6.487D-01  6.302D-01  1.171D 00  1.230D 01  3.893D 01  3.893D 01  0.0          6.302D-01  6.3020-01
 14 14 15  0  1  1.2580 01  6.590D-01  6.401D-01  1.584D 00  1.056D 01  4.017D 01  4.017D 01  0.0          6.401D-01  6.401D-01
 15 12 16  1  1  6.485D 00  3.406D-01  2.826D-01  4.124D 00  5.634D-01  7.170D 00  7.170D 00  0.0          2.826D-01  2.8260-01
 16 14 17  1  1  6.4850 00  3.406D-01  2.826D-01  4.124D 00  5.6340-01  7.169D 00  7.169D 00  0.0          2.826D-01  2.826D-01
 17 11 18  2  0  1.0590 04  2.228D-01  2.228D-D1  2.066D-03  2.066D-03  6.618D 00  6.618D 00  0.0          2.223D-01  2.228D-01
 18 11 18  3  0  1.0590 04  2.228D-01  2.228D-01  2.066D-03  2.066D-03  6.618D 00  6.618D 00  0.0          2.228D-01  2.228D-01
 19  2 19  1  0  2.051D 03  1.564D-01  1.564D-01  5.260D-03  5.260D-03  3.262D 00  3.262D 00  0.0          1.564D-01  1.564D-01
 20  6 12  0  0  3.316D 00  1.024D 00  9.944D-01  4.603D 00  4.833D 01  9.695D 01  9.695D 01  0.0          9.944D-01  9.944D-01
 21  9 14  0  0  2.927D 00  2.320D 00  2.254D 00  5.357D 01  5.625D 02  4.979D 02  4.979D 02  D.0          2.254D 00  2.254D 00
 22 12  0  0  0  3.5690 00  1.902D 00  1.848D 00  2.954D 01  3.101D 02  3.348D 02  3.348D 02  0.0          1.848D 00  1.848D 00
 23  2 20  0  0  9.742D 00  3.185D-01  3.185D-01  1.524D 00  1.524D 00  2.113D 00  2.113D 00  0.0          3.185D-01  3.185D-01
 24  2 21  0  0  1.508D 01  3.200D-01  3.200D-01  9.940D-01  9.940D-01  2.133D 00  2.133D 00  0.0          3.200D-01  3.200D-01
 25 15 16  0  0  0.0        2.036D 00  1.977D 00  0.0        0.0        0.0        0.0        0.0          0.0        0.0
 26 15 16  2  2  0.0        2.036D 00  1.977D 00  0.0        0.0        0.0        0.0        0.0          0.0        0.0
 27 15  0  0  0  1.600D 00  5.181D 00  5.033D 00  7.698D 02  5.132D 03  2.484D 03  2.484D 03  0.0          5.033D 00  5.033D 00
 28 15  0  2  0  1.600D 00  5.181D 00  5.033D 00  7.698D 02  5.132D 03  2.484D 03  2.484D 03  0.0          5.033D 00  5.033D 00


OVERALL VEHICLE FORCES AND ACCELS(G-S), A/P AXES

  FX=   -1.91571D 03    AX=   -1.02688D-02
  FY=    0.0            AY=    0.0
  FZ=    4.09109D 03    AZ=    2.19296D-02
  MX=    0.0           PDT=    0.0
  MY=   -1.452480 05   QDT=   -3.74394D-03
  MZ=    0.0           RDT=    0.0


OVERALL VEHICLE FORCES AND ACCELS(G-S), INCLUDING INERTIA RELIEF, A/P AXES

  FX=   -1.725290-13    AX=   -9.24809D-19
  FY=    0.0            AY=    0.0
  FZ=    5.115910-12    AZ=    2.74229D-17
  MX=    0.0           PDT=    0.0
  MY=    8.29459D-10   QDT=    2.13803D-17
  MZ=    0.0           RDT=    0.0


INDIVIDUAL MASS FORCES/MOMENTS AND ACCELS
GRAVITY/EXTERNAL/LIFT/INERTIA/NET/ACCELS(G-S)
```

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 5)

```
ACCELS IN MASS AXES, ALL OTHERS IN A/P AXES

MASS          X              Y              Z              L              M              N

  1     -2.76568D 01    0.0           1.58476D 03    0.0            0.0            0.0
         2.12825D-01    0.0          -9.49998D 01    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         4.25797D 01    0.0          -4.50550D 01    0.0            1.49758D 02    0.0
         1.51357D 01    0.0           1.44470D 03    0.0            1.49758D 02    0.0
        -2.68004D-02    0.0           2.84860D-02    0.0           -3.74394D-03    0.0

  2     -1.58167D 02    0.0           9.06312D 03    0.0            0.0            0.0
         1.39164D 00    0.0          -6.24498D 02    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         2.19886D 02    0.0          -2.48534D 02    0.0            1.12318D 03    0.0
         6.31105D 01    0.0           8.19009D 03    0.0            1.12318D 03    0.0
        -2.41968D-02    0.0           2.74724D-02    0.0           -3.74394D-03    0.0

  3     -2.67287D 02    0.0           1.53158D 04    0.0            0.0            0.0
         3.75300D 00    0.0          -1.86100D 03    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         3.09518D 02    0.0          -3.92391D 02    0.0            3.62919D 02    0.0
         4.59834D 01    0.0           1.30624D 04    0.0            3.62919D 02    0.0
        -2.01543D-02    0.0           2.56569D-02    0.0           -3.74394D-03    0.0

  4     -2.28514D 02    0.0           1.30940D 04    0.0            0.0            0.0
         6.17764D 00    0.0          -4.71500D 03    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         2.10641D 02    0.0          -3.14323D 02    0.0            2.49777D 02    0.0
        -1.16955D 01    0.0           8.06469D 03    0.0            2.49777D 02    0.0
        -1.60529D-02    0.0           2.40225D-02    0.0           -3.74394D-03    0.0

  5     -3.79564D 02    0.0           2.17493D 04    0.0            0.0            0.0
         0.0            0.0          -7.90100D 03    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         2.38359D 02    0.0          -4.76710D 02    0.0            4.70501D 02    0.0
        -1.41205D 02    0.0           1.33716D 04    0.0            4.70501D 02    0.0
        -1.09577D-02    0.0           2.19151D-02    0.0           -3.74394D-03    0.0

  6     -1.37874D 02    0.0           7.90030D 03    0.0            0.0            0.0
        -3.79430D 00    0.0          -1.99100D 03    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         5.69998D 01    0.0          -1.64901D 02    0.0            4.49273D 02    0.0
        -8.46687D 01    0.0           5.74440D 03    0.0            4.49273D 02    0.0
        -7.25355D-03    0.0           2.08558D-02    0.0           -3.74394D-03    0.0

  7     -1.60370D 02    0.0           9.18930D 03    0.0            0.0            0.0
        -6.12849D 00    0.0          -2.31599D 03    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         4.76734D 01    0.0          -1.83561D 02    0.0            5.24152D 02    0.0
        -1.18825D 02    0.0           6.68975D 03    0.0            5.24152D 02    0.0
        -5.23997D-03    0.0           1.99587D-02    0.0           -3.74394D-03    0.0

  8     -1.73416D 02    0.0           9.93689D 03    0.0            0.0            0.0
        -3.08309D 00    0.0          -7.85394D 02    0.0            0.0            0.0
         0.0            0.0           0.0            0.0            0.0            0.0
         8.74043D 00    0.0          -1.87359D 02    0.0            6.73910D 02    0.0
        -1.67759D 02    0.0           8.96413D 03    0.0            6.73910D 02    0.0
        -9.53457D-04    0.0           1.88484D-02    0.0           -3.743940-03    0.0
```

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 3 OF 5)

```
  9   -9.94949D 01    0.0            5.70113D 03    0.0            0.0            0.0
      -2.60603D 00    0.0           -4.49992D 02    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
      -2.05134D 01    0.0           -1.03682D 02    0.0            1.56452D 02    0.0
      -1.22614D 02    0.0            5.14746D 03    0.0            1.56452D 02    0.0
       3.49222D-03    0.0            1.82039D-02    0.0           -3.74394D-03    0.0

 10   -1.07752D 02    0.0            6.17426D 03    0.0            0.0            0.0
       1.11310D 02    0.0            1.74452D 04    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
      -5.83230D 01    0.0           -1.062460 02    0.0            4.04271D 02    0.0
      -5.47649D 01    0.0            2.351330 04    0.0            4.04271D 02    0.0
       9.33475D-03    0.0            1.72652D-02    0.0           -3.74394D-03    0.0

 11   -1.68743D 02    0.0            9.66913D 03    0.0            0.0            0.0
       3.38858D 01    1.03215D 02   -1.54188D 04    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       1.11732D 02    0.0           -2.10821D 02    1.45761D 01    5.18873D 02   -6.208550 00
      -2.31254D 01    1.03215D 02   -5.96051D 03    1.45761D 01    5.18873D 02   -6.208550 00
      -1.15058D-02    1.52548D-04    2.18250D-02   -2.09868D-06   -3.74386D-03    2.506170-05

 12   -1.75636D 02    0.0            1.00641D 04    0.0            0.0            0.0
       1.87699D 02    3.68310D 02   -2.81852D 04    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       1.01418D 02    0.0           -2.18823D 02    2.28770D 01    4.59233D 02   -9.485500 00
       1.13481D 02    3.68310D 02   -1.83399D 04    2.28770D 01    4.59233D 02   -9.48550D 00
      -9.93049D-03    2.94185D-04    2.18044D-02   -3.49146D-06   -3.74362D-03    4.891870-05

 13   -9.22447D 01    0.0            5.28570D 03    0.0            0.0            0.D
       2.19950D 02    4.79829D 02   -2.13876D 04    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       3.97697D 01    0.0           -1.13095D 02    1.26375D 01    1.97110D 02   -5.44988D 00
       1.67475D 02    4.79829D 02   -1.62150D 04    1.26375D 01    1.97110D 02   -5.44988D 00
      -7.30167D-03    4.93800D-04    2.14641D-02   -6.29525D-06   -3.74300D-03    8.396950-05

 14   -6.55912D 01    0.0            3.75843D 03    0.0            0.0            0.0
       1.29292D 02    4.57283D 02   -1.78125D 04    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       1.73600D 01    0.0           -7.94689D 01    8.37535D 00    9.67618D 01   -4.35614D 00
       8.10609D 01    4.57283D 02   -1.41335D 04    8.37535D 00    9.67618D 01   -4.35614D 00
      -4.46175D-03    5.67031D-04    2.11670D-02   -1.98276D-05   -3.74266D-03    9.60807D-05

 15   -2.69118D 01    0.0            1.54207D 03    0.0            0.0            0.0
       5.60559D 01    1.06988D 02   -6.23973D 03    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       4.26908D 00    0.0           -3.22366D 01    1.41331D 00    3.37560D 01   -9.25661D-01
       3.34132D 01    1.06988D 02   -4.72990D 03    1.41331D 00    3.375600 01   -9.25661D-01
      -2.57832D-03    3.71434D-04    2.09226D-02   -1.84388D-05   -3.74335D-03    6.41825D-05

 16   -9.42252D 01    0.0            5.39918D 03    0.0            0.0            0.0
      -5.60265D 00   -2.05753D 01   -2.69959D 02    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       7.49904D 01    0.0           -1.19086D 02    2.41058D 02    9.62259D 01    9.971360 03
      -2.48374D 01   -2.05753D 01    5.01013D 03    2.41058D 02    9.62259D 01    9.97136D 03
      -1.44105D-02   -8.69527D-04    2.16971D-02   -2.033810-04   -3.72758D-03   -2.84463D-04

 17   -8.98804D 01    0.0            5.15022D 03    0.0            0.0            0.0
      -5.13129D 00   -1.645120 01   -2.57724D 02    0.0            0.0            0.0
       0.0            0.0            0.0            0.0            0.0            0.0
       4.56499D 01    0.0           -1.083470 02    2.29263D 02    9.18382D 01    9.96840D 03
```

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 4 OF 5)

```
        -4.93618D 01   -1.64512D 01    4.78414D 03    2.29263D 02    9.18382D 01    9.96840D 03
        -9.34166D-03   -7.76184D-04    2.08112D-02   -2.21321D-04   -3.72978D-03   -2.38453D-04

 18     -3.35372D 01    0.0            1.92171D 03    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         1.97452D 01    0.0           -3.54470D 01    2.42191D-02    5.99037D 00   -1.68548D-02
        -1.37920D 01    0.0            1.88626D 03    2.42191D-02    5.99037D 00   -1.68548D-02
        -1.02326D-02    1.29277D-04    1.84649D-02   -2.09858D-06   -3.74386D-03    2.50486D-05

 19     -4.15289D 00    0.0            2.37964D 02    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         6.20994D 00    0.0           -5.74830D 00    0.0            1.12318D 00    0.0
         2.05705D 00    0.0            2.32215D 02    0.0            1.12318D 00    0.0
        -2.60384D-02    0.0            2.42105D-02    0.0           -3.74394D-03    0.0

 20     -1.74491D 01    0.0            9.99848D 02    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         2.40667D 01    0.0           -2.79347D 01    0.0            3.74394D 00    0.0
         6.61759D 00    0.0            9.71913D 02    0.0            3.74394D 00    0.0
        -2.39509D-02    0.0            2.80341D-02    0.0           -3.74394D-03    0.0

 21      0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
```

FIGURE 2-10. MISCELLANEOUS CALCULATED DATA (SHEET 5 OF 5)

```
                                                                   AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83    PAGE      1

        N A S T R A N    E X E C U T I V E    C O N T R O L    D E C K    E C H O


      ID MAGAMON,D7612
      SOL 24
      DIAG 8
      CEND

    *** USER WARNING MESSAGE 4519, A TIME CARD IS MISSING. DEFAULT TIME LIMIT IS ONE MINUTE.
```

FIGURE 2-11. MSC/NASTRAN EXECUTIVE AND CASE CONTROL DECKS (SHEET 1 OF 2)

```
LT.SAMPLE.DATA                                              AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     2
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                          C A S E   C O N T R O L   D E C K   E C H O
             CARD
             COUNT
               1      TITLE=LT.SAMPLE.DATA
               2      SUBTITLE=21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL
               3      LABEL=INITIAL CONDITION STATIC SOLUTION
               4      LOAD=10
               5      ECHO=BOTH
               6      OUTPUT
               7          DISPLACEMENT(PRINT,PUNCH)=ALL
               8          SPCFORCES=ALL
               9          ELFORCE=ALL
              10          GPFORCE=ALL
              11          ESE=ALL
              12          OLOAD=ALL
              13      BEGIN BULK
```

FIGURE 2-11. MSC/NASTRAN EXECUTIVE AND CASE CONTROL DECKS (SHEET 2 OF 2)

```
LT.SAMPLE.DATA                                        AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     3
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                I N P U T   B U L K   D A T A   D E C K   E C H O

.   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
$
$     KRASH MASS POINTS CONVERTED TO NASTRAN GRID CARDS
$
GRID*        100                          198.9691085700    0.0         *   100G
*   100G  219.0072894000                             246
GRID*        200                          299.9715105900    0.0         *   200G
*   200G  217.9331623000                             246
GRID*        300                          459.9920437930    0.0         *   300G
*   300G  208.2776436000                             246
GRID*        400                          619.9961184340    0.0         *   400G
*   400G  205.8532906000                             246
GRID*        500                          820.0000000000    0.0         *   500G
*   500G  200.2000000000                          123456
GRID*        600                          960.0003900044    0.0         *   600G
*   600G  212.2604349000                             246
GRID*        700                         1039.9825895500    0.0         *   700G
*   700G  207.5775777000                             246
GRID*        800                         1200.0196003700    0.0         *   800G
*   800G  224.2425320000                             246
GRID*        900                         1360.0623369000    0.0         *   900G
*   900G  258.3539810000                             246
GRID*       1000                         1570.4121330000    0.0         *  1000G
*  1000G  299.3524450000                             246
GRID*       1100                          801.2762329200 -118.3620482900*  1100G
*  1100G  188.7549811000                               0
GRID*       1200                          852.0816817000 -271.7586170000*  1200G
*  1200G  205.4417780000                               0
GRID*       1300                          942.8991904000 -430.3945420000*  1300G
*  1300G  226.0702350000                               0
GRID*       1400                         1044.4314080000 -582.8600137000*  1400G
*  1400G  254.3458500000                               0
GRID*       1500                         1110.1047930000 -740.1657271000*  1500G
*  1500G  269.6958900000                               0
GRID*       1600                          719.0791973500 -321.8893812000*  1600G
*  1600G  167.7378190000                               0
GRID*       1700                          902.1047448000 -551.6346446100*  1700G
*  1700G  196.9346760000                               0
GRID*       1800                          887.1832870000 -132.3628592000*  1800G
*  1800G   91.3225001000                               0
GRID*       1900                          279.2696309000    0.0         *  1900G
*  1900G   84.1201432000                             246
GRID*       2000                          299.9019012500    0.0         *  2000G
*  2000G  237.8378928000                             246
GRID*       2100                          299.9269427700    0.0         *  2100G
*  2100G  237.9330628000                               0
$
$     KRASH MASSLESS NODE POINTS CONVERTED TO NASTRAN GRIDS
$
GRID*        501                          775.1000000000  -48.0000000000*   501G
*   501G  181.0000000000                               0
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 1 OF 11)

```
LT.SAMPLE.DATA                                                     AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     4
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                   I N P U T   B U L K   D A T A   D E C K   E C H O

                 .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                 GRID*          1101                          773.8807694600 -118.3604807600*  1101G
                 *  1101G  186.6946611000                                  0
                 GRID*          1102                          886.9870388800 -131.7657883000*  1102G
                 *  1102G  180.4333756000                                  0
                 GRID*          1103                          886.9870388800 -131.7657883000*  1103G
                 *  1103G  180.4333756000                                  0
                 GRID*          1201                          811.5560511000 -321.5615706000*  1201G
                 *  1201G  202.3218480000                                  0
                 GRID*          1401                          993.4773320000 -551.3099517000*  1401G
                 *  1401G  230.1605510000                                  0
                 GRID*          1501                         1145.4453490000 -740.2282724000*  1501G
                 *  1501G  276.2174300000                                  0
                 GRID*          1502                         1110.1047930000 -740.1657271000*  1502G
                 *  1502G  269.6958900000                                  0
                 GRID*          1601                          735.4614452000 -321.4752190000*  1601G
                 *  1601G  201.6861040000                                  0
                 GRID*          1602                          719.0791973500 -321.8893812000*  1602G
                 *  1602G  167.7378190000                                  0
                 GRID*          1701                          917.3858480000 -550.9002126000*  1701G
                 *  1701G  229.4678850000                                  0
                 GRID*           201                          279.1302763000    0.0         *   201G
                 *   201G  146.6867195000                                  0
                 $
                 $      KRASH MASS POINT/NODE POINTS CONVERTED TO RBAR ELEMENTS
                 $
                 RBAR         501     500     501  123456                  123456
                 PLOTEL       501     500     501
                 RBAR        1101    1100    1101  123456                  123456
                 PLOTEL      1101    1100    1101
                 RBAR        1102    1100    1102  123456                  123456
                 PLOTEL      1102    1100    1102
                 RBAR        1103    1100    1103  123456                  123456
                 PLOTEL      1103    1100    1103
                 RBAR        1201    1200    1201  123456                  123456
                 PLOTEL      1201    1200    1201
                 RBAR        1401    1400    1401  123456                  123456
                 PLOTEL      1401    1400    1401
                 RBAR        1501    1500    1501  123456                  123456
                 PLOTEL      1501    1500    1501
                 RBAR        1502    1500    1502  123456                  123456
                 PLOTEL      1502    1500    1502
                 RBAR        1601    1600    1601  123456                  123456
                 PLOTEL      1601    1600    1601
                 RBAR        1602    1600    1602  123456                  123456
                 PLOTEL      1602    1600    1602
                 RBAR        1701    1700    1701  123456                  123456
                 PLOTEL      1701    1700    1701
                 RBAR         201     200     201  123456                  123456
                 PLOTEL       201     200     201
                 $
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 2 OF 11)

```
LT.SAMPLE.DATA                                                        AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83    PAGE     5
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                        I N P U T   B U L K   D A T A   D E C K   E C H O

                            .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                            $    KRASH MASS POINTS CONVERTED TO NASTRAN CONM2 CARDS
                            $
                            CONM2        100     100             2.053                           WT  100
                            +WT  100   5757.      0.  20000.      0.              0.   7500.
                            CONM2        200     200            11.742                           WT  200
                            +WT  200  44540.      0. 150000.      0.              0.  49500.
                            CONM2        300     300            19.842                           WT  300
                            +WT  300  81390.      0.  48468.      0.              0.  51545.
                            CONM2        400     400            16.964                           WT  400
                            +WT  400  98135.      0.  33358.      0.              0.  39695.
                            CONM2        500     500            28.177                           WT  500
                            +WT  500 245530.      0.  62835.      0.              0.  73255.
                            CONM2        600     600            10.235                           WT  600
                            +WT  600  40692.      0.  60000.      0.              0. 100000.
                            CONM2        700     700            11.905                           WT  700
                            +WT  700  43768.      0.  70000.      0.              0. 100000.
                            CONM2        800     800            12.874                           WT  800
                            +WT  800  44049.      0.  90000.      0.              0. 150000.
                            CONM2        900     900             7.386                           WT  900
                            +WT  900  48125.      0.  20894.      0.              0.  13020.
                            CONM2       1000    1000             7.999                           WT 1000
                            +WT 1000 107650.      0.  53990.      0.              0.  79315.
                            CONM2       1100    1100            25.053                           WT 1100
                            +WT 1100  15213.      0. 138580.      0.              0. 360000.
                            CONM2       1200    1200            26.077                           WT 1200
                            +WT 1200  19510.      0. 122630.      0.              0. 300000.
                            CONM2       1300    1300            13.696                           WT 1300
                            +WT 1300   7272.      0.  52619.      0.              0. 110000.
                            CONM2       1400    1400             9.738                           WT 1400
                            +WT 1400   4408.      0.  25823.      0.              0.  60000.
                            CONM2       1500    1500             3.996                           WT 1500
                            +WT 1500   1671.      0.   9014.      0.              0.  18000.
                            CONM2       1600    1600            13.990                           WT 1600
                            +WT 1600   3652.      0.  25746.      0.              0.  29375.
                            CONM2       1700    1700            13.345                           WT 1700
                            +WT 1700   3712.      0.  24588.      0.              0.  28178.
                            CONM2       1800    1800             4.979                           WT 1800
                            +WT 1800    371.      0.   1600.      0.              0.   2000.
                            CONM2       1900    1900             0.308                           WT 1900
                            +WT 1900     12.      0.    150.      0.              0.    250.
                            CONM2       2000    2000             1.295                           WT 2000
                            +WT 2000    500.      0.    500.      0.              0.    500.
                            CONM2       2100    2100             1.295                           WT 2100
                            +WT 2100    500.      0.    500.      0.              0.    500.
                            $
                            $     KRASH SYMMETRIC MODEL BOUNDARY POINTS CONVERTED TO NASTRAN GROUNDED GRIDS
                            $
                            GRID*       1199                          852.0816817000     0.0          *  1199G
                            *  1199G 205.4417780000                              246
                            GRID*       1499                         1110.1047930000     0.0          *  1499G
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 3 OF 11)

```
LT.SAMPLE.DATA                                                  AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE     6
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                  I N P U T   B U L K   D A T A   D E C K   E C H O

               .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
               *  1499G  269.6958900000                             246
               GRID*       1498                         1110.1047930000    0.0         *  1498G
               *  1498G  269.6958900000                             246
               $
               $     KRASH BEAM ELEMENTS CONVERTED TO NASTRAN CBAR, PBAR, AND MAT1 CARDS
               $
               CBAR*       1000            1000             100             200        *  1000S
               *  1000S  0.0            -1.000000000000  0.0                           *  1000T
               *  1000T                                                                *  1000U
               *  1000U
               PBAR*               1000            1000     16.00000000  18500.00000000*  1000A
               *  1000A  31000.00000000  49500.00000000
               MAT1*               1000     10000000.00      3800000.00                *  1000B
               *  1000B                                                   0.100000000000*  1000C
               *  1000C       35000.000       34000.000       17000.000
               $
               CBAR*       2000            2000             200             300        *  2000S
               *  2000S  0.0            -1.000000000000  0.0                           *  2000T
               *  2000T                                                                *  2000U
               *  2000U
               PBAR*               2000            2000     18.00000000  21500.00000000*  2000A
               *  2000A  38500.00000000  60000.00000000
               MAT1*               2000     10000000.00      3800000.00                *  2000B
               *  2000B                                                   0.100000000000*  2000C
               *  2000C       35000.000       34000.000       17000.000
               $
               CBAR*       3000            3000             300             400        *  3000S
               *  3000S  0.0            -1.000000000000  0.0                           *  3000T
               *  3000T                                                                *  3000U
               *  3000U
               PBAR*               3000            3000     18.00000000  21500.00000000*  3000A
               *  3000A  43000.00000000  64500.00000000
               MAT1*               3000     10000000.00      3800000.00                *  3000B
               *  3000B                                                   0.100000000000*  3000C
               *  3000C       35000.000       34000.000       17000.000
               $
               CBAR*       4000            4000             400             500        *  4000S
               *  4000S  0.0            -1.000000000000  0.0                           *  4000T
               *  4000T                                                                *  4000U
               *  4000U
               PBAR*               4000            4000     29.50000000  23250.00000000*  4000A
               *  4000A  68000.00000000  91250.00000000
               MAT1*               4000     10000000.00      3800000.00                *  4000B
               *  4000B                                                   0.100000000000*  4000C
               *  4000C       35000.000       34000.000       17000.000
               $
               CBAR*       5000            5000             500             600        *  5000S
               *  5000S  0.0            -1.000000000000  0.0                           *  5000T
               *  5000T                                                                *  5000U
               *  5000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 4 OF 11)

```
LT.SAMPLE.DATA                                                              AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83    PAGE      7
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                        I N P U T   B U L K   D A T A   D E C K   E C H O

                         .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                         PBAR*                   5000            5000     29.50000000 23250.00000000*  5000A
                         *  5000A  58000.00000000  81250.00000000
                         MAT1*                   5000     10000000.00      3800000.00                *  5000B
                         *  5000B                                                 0.100000000000*  5000C
                         *  5000C       35000.000       34000.000       17000.000
                         $
                         CBAR*       6000            6000            600             700             *  6000S
                         *  6000S  0.0            -1.000000000000  0.0                               *  6000T
                         *  6000T                                                                    *  6000U
                         *  6000U
                         PBAR*                   6000            6000     28.50000000 28500.00000000*  6000A
                         *  6000A  68000.00000000  96500.00000000
                         MAT1*                   6000     10000000.00      3800000.00                *  6000B
                         *  6000B                                                 0.100000000000*  6000C
                         *  6000C       35000.000       34000.000       17000.000
                         $
                         CBAR*       7000            7000            700             800             *  7000S
                         *  7000S  0.0            -1.000000000000  0.0                               *  7000T
                         *  7000T                                                                    *  7000U
                         *  7000U
                         PBAR*                   7000            7000     24.00000000 31000.00000000*  7000A
                         *  7000A  57000.00000000  88000.00000000
                         MAT1*                   7000     10000000.00      3800000.00                *  7000B
                         *  7000B                                                 0.100000000000*  7000C
                         *  7000C       35000.000       34000.000       17000.000
                         $
                         CBAR*       8000            8000            800             900             *  8000S
                         *  8000S  0.0            -1.000000000000  0.0                               *  8000T
                         *  8000T                                                                    *  8000U
                         *  8000U
                         PBAR*                   8000            8000     18.50000000 16750.00000000*  8000A
                         *  8000A  28000.00000000  44750.00000000
                         MAT1*                   8000     10000000.00      3800000.00                *  8000B
                         *  8000B                                                 0.100000000000*  8000C
                         *  8000C       35000.000       34000.000       17000.000
                         $
                         CBAR*       9000            9000            900             1000            *  9000S
                         *  9000S  0.0            -1.000000000000  0.0                               *  9000T
                         *  9000T                                                                    *  9000U
                         *  9000U
                         PBAR*                   9000            9000     12.50000000  4750.00000000*  9000A
                         *  9000A  45000.00000000  49750.00000000
                         MAT1*                   9000     10000000.00      3800000.00                *  9000B
                         *  9000B                                                 0.100000000000*  9000C
                         *  9000C       35000.000       34000.000       17000.000
                         $
                         CBAR*      10000           10000            500             1101            * 10000S
                         * 10000S -0.931764722640  0.363062669031  0.0                               * 10000T
                         * 10000T                                                                    * 10000U
                         * 10000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 5 OF 11)

```
                              I N P U T   B U L K   D A T A   D E C K   E C H O

          . 1 ..  2  ..  3  ..  4  ..  5  ..  6  ..  7  ..  8  ..  9  ..  10  .
          PBAR*            10000           10000      54.00000000 114000.00000000* 10000A
          * 10000A 15900.00000000  48000.00000000
          MAT1*            10000      10000000.00      3800000.00                 * 10000B
          * 10000B                                                0.100000000000* 10000C
          * 10000C       35000.000       34000.000       17000.000
          $
          CBAR*     11000           11000           1101            1200          * 11000S
          * 11000S -0.890910986066 -0.454177955109  0.0                           * 11000T
          * 11000T                                                                * 11000U
          * 11000U
          PBAR*            11000           11000      63.20000000 102000.00000000* 11000A
          * 11000A 11400.00000000  26000.00000000
          MAT1*            11000      10000000.00      3800000.00                 * 11000B
          * 11000B                                                0.100000000000* 11000C
          * 11000C       35000.000       34000.000       17000.000
          $
          CBAR*     12000           12000           1200            1300          * 12000S
          * 12000S -0.867845992474 -0.496833305392  0.0                           * 12000T
          * 12000T                                                                * 12000U
          * 12000U
          PBAR*            12000           12000      56.30000000  58000.00000000* 12000A
          * 12000A  4700.00000000  10000.00000000
          MAT1*            12000      10000000.00      3800000.00                 * 12000B
          * 12000B                                                0.100000000000* 12000C
          * 12000C       35000.000       34000.000       17000.000
          $
          CBAR*     13000           13000           1300            1400          * 13000S
          * 13000S -0.832330947833 -0.554278985060  0.0                           * 13000T
          * 13000T                                                                * 13000U
          * 13000U
          PBAR*            13000           13000      40.70000000  21000.00000000* 13000A
          * 13000A  2000.00000000   4800.00000000
          MAT1*            13000      10000000.00      3800000.00                 * 13000B
          * 13000B                                                0.100000000000* 13000C
          * 13000C       35000.000       34000.000       17000.000
          $
          CBAR*     14000           14000           1400            1501          * 14000S
          * 14000S -0.841546482505 -0.540184707099  0.0                           * 14000T
          * 14000T                                                                * 14000U
          * 14000U
          PBAR*            14000           14000      20.00000000   8000.00000000* 14000A
          * 14000A  1200.00000000   2700.00000000
          MAT1*            14000      10000000.00      3800000.00                 * 14000B
          * 14000B                                                0.100000000000* 14000C
          * 14000C       35000.000       34000.000       17000.000
          $
          CBAR*     15000           15000           1201            1601          * 15000S
          * 15000S 0.001134791926  0.999999356123  0.0                            * 15000T
          * 15000T                                                                * 15000U
          * 15000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 6 OF 11)

```
LT.SAMPLE.DATA                                                          AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83   PAGE      9
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                         I N P U T   B U L K   D A T A   D E C K   E C H O

                        .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                        PBAR*              15000            15000       8.00000000     100.00000000* 15000A
                        * 15000A    732.00000000     220.80000000
                        MAT1*              15000      10500000.00       4000000.00                 * 15000B
                        * 15000B                                                    0.100000000000* 15000C
                        * 15000C       47000.000        39000.000        22000.000
                        $
                        CBAR*      16000            16000            1401             1701         * 16000S
                        * 16000S  0.005384743970   0.999985502161  0.0                              * 16000T
                        * 16000T                                                                    * 16000U
                        * 16000U
                        PBAR*              16000            16000       8.00000000     100.00000000* 16000A
                        * 16000A    732.00000000     220.80000000
                        MAT1*              16000      10500000.00       4000000.00                 * 16000B
                        * 16000B                                                    0.100000000000* 16000C
                        * 16000C       47000.000        39000.000        22000.000
                        $
                        CBAR*      17000            17000            1102             1800         * 17000S
                        * 17000S  0.0             -0.999977553648  0.006700164201                  * 17000T
                        * 17000T                                                                    * 17000U
                        * 17000U
                        PBAR*              17000            17000       0.29919509     239.00000000* 17000A
                        * 17000A    239.00000000     150.00000000
                        MAT1*              17000      30000000.00      11000000.00                 * 17000B
                        * 17000B                                                    0.100000000000* 17000C
                        * 17000C       75000.000        75000.000        37500.000
                        $
                        CBAR*      18000            18000            1103             1800         * 18000S
                        * 18000S  0.0             -0.999977553648  0.006700164201                  * 18000T
                        * 18000T                                                                    * 18000U
                        * 18000U
                        PBAR*              18000            18000       0.01000000     239.00000000* 18000A
                        * 18000A    239.00000000     150.00000000
                        MAT1*              18000      30000000.00      11000000.00                 * 18000B
                        * 18000B                                                    0.100000000000* 18000C
                        * 18000C       75000.000        75000.000        37500.000
                        $
                        CBAR*      19000            19000            201              1900         * 19000S
                        * 19000S  0.0             -1.000000000000  0.0                              * 19000T
                        * 19000T                                                                    * 19000U
                        * 19000U
                        PBAR*              19000            19000       0.05243324      16.25000000* 19000A
                        * 19000A     16.25000000       2.50000000
                        MAT1*              19000      30000000.00      11000000.00                 * 19000B
                        * 19000B                                                    0.100000000000* 19000C
                        * 19000C       75000.000        75000.000        37500.000
                        $
                        CBAR*      20000            20000            600              1200         * 20000S
                        * 20000S -0.929399243434   0.369075935688  0.0                              * 20000T
                        * 20000T                        56                                          * 20000U
                        * 20000U
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 7 OF 11)

```
LT.SAMPLE.DATA                                                          AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    10
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                         I N P U T   B U L K   D A T A   D E C K   E C H O

                         .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                         PBAR*              20000           20000     40.70000000  21000.00000000* 20000A
                         * 20000A   2000.00000000   4800.00000000
                         MAT1*              20000     10000000.00      3800000.00                * 20000B
                         * 20000B                                                  0.100000000000* 20000C
                         * 20000C       35000.000       34000.000       17000.000
                         $
                         CBAR*      21000           21000             900            1400        * 21000S
                         * 21000S -0.879345610002  0.476184101131  0.0                           * 21000T
                         * 21000T       6               6                                        * 21000U
                         * 21000U
                         PBAR*              21000           21000     40.70000000  21000.00000000* 21000A
                         * 21000A   2000.00000000   4800.00000000
                         MAT1*              21000     10000000.00      3800000.00                * 21000B
                         * 21000B                                                  0.100000000000* 21000C
                         * 21000C       35000.000       34000.000       17000.000
                         $
                         CBAR*      22000           22000           1200             1199        * 22000S
                         * 22000S  1.000000000000  0.000000000000  0.0                           * 22000T
                         * 22000T                                                                * 22000U
                         * 22000U
                         PBAR*              22000           22000     40.70000000  21000.00000000* 22000A
                         * 22000A   2000.00000000   4800.00000000
                         MAT1*              22000     10000000.00      3800000.00                * 22000B
                         * 22000B                                                  0.100000000000* 22000C
                         * 22000C       35000.000       34000.000       17000.000
                         $
                         CBAR*      23000           23000             200            2000        * 23000S
                         * 23000S  0.0             1.000000000000  0.0                           * 23000T
                         * 23000T                                                                * 23000U
                         * 23000U
                         PBAR*              23000           23000      0.10178943      0.50000000* 23000A
                         * 23000A      0.50000000      0.50000000
                         MAT1*              23000      1000000.00       400000.00                * 23000B
                         * 23000B                                                  0.632230474716* 23000C
                         * 23000C       16000.000       16000.000       17000.000
                         $
                         $
                         $     DRI MASSES CONNECTED WITH RBAR ELEMENTS
                         $
                         RBAR       24000     200    2100  123456                  123456
                         CBAR*      25000           25000            1500            1600        * 25000S
                         * 25000S  0.730502420322  0.682910106752  0.0                           * 25000T
                         * 25000T                                                                * 25000U
                         * 25000U
                         PBAR*              25000           25000      0.0             0.0       * 25000A
                         * 25000A      0.0             0.0
                         MAT1*              25000     10000000.00      3800000.00                * 25000B
                         * 25000B                                                  0.100000000000* 25000C
                         * 25000C       35000.000       34000.000       17000.000
                         $
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 8 OF 11)

```
LT.SAMPLE.DATA                                                           AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    11
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                          I N P U T   B U L K   D A T A   D E C K   E C H O

                          .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                          CBAR*      26000           26000           1502            1602            * 26000S
                          * 26000S  0.730502420322  0.682910106752  0.0                           * 26000T
                          * 26000T                                                                * 26000U
                          * 26000U
                          PBAR*              26000           26000      0.0             0.0       * 26000A
                          * 26000A      0.0             0.0
                          MAT1*              26000     10000000.00      3800000.00                * 26000B
                          * 26000B                                                  0.100000000000* 26000C
                          * 26000C       35000.000       34000.000       17000.000
                          $
                          CBAR*      27000           27000           1500            1499            * 27000S
                          * 27000S  1.000000000000  0.000000000000  0.0                           * 27000T
                          * 27000T                                                                * 27000U
                          * 27000U
                          PBAR*              27000           27000      0.0          8000.00000000* 27000A
                          * 27000A   1200.00000000   2700.00000000
                          MAT1*              27000     10000000.00      3800000.00                * 27000B
                          * 27000B                                                  0.100000000000* 27000C
                          * 27000C       35000.000       34000.000       17000.000
                          $
                          CBAR*      28000           28000           1502            1498            * 28000S
                          * 28000S  1.000000000000  0.000000000000  0.0                           * 28000T
                          * 28000T                                                                * 28000U
                          * 28000U
                          PBAR*              28000           28000     20.00000000   8000.00000000* 28000A
                          * 28000A   1200.00000000   2700.00000000
                          MAT1*              28000     10000000.00      3800000.00                * 28000B
                          * 28000B                                                  0.100000000000* 28000C
                          * 28000C       35000.000       34000.000       17000.000
                          $
                          $
                          $    MISCELLANEOUS CARDS
                          $
                          EIGR    999     MGIV                            40                       EIGR
                          +EIGR   MAX
                          $
                          $    FORCE AND MOMENT CARDS, BASED ON FNET CALCS
                          $
                          FORCE*         1               100                            1.0       *  1000M
                          *  1000M     -7.56785966      0.0          -722.35195283
                          MOMENT*        2               100                            1.0       *  1000N
                          *  1000N       0.0           74.8788473       0.0
                          FORCE*         1               200                            1.0       *  2000M
                          *  2000M    -31.55523283      0.0         -4095.04371998
                          MOMENT*        2               200                            1.0       *  2000N
                          *  2000N       0.0          561.5913546       0.0
                          FORCE*         1               300                            1.0       *  3000M
                          *  3000M    -22.99168396      0.0         -6531.19035496
                          MOMENT*        2               300                            1.0       *  3000N
                          *  3000N       0.0          181.4595265       0.0
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 9 OF 11)

```
LT.SAMPLE.DATA                                                      AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    12
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                  I N P U T   B U L K   D A T A   D E C K   E C H O

                    .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                    FORCE*          1               400                                 1.0             *  4000M
                    *  4000M      5.84772882      0.0             -4032.34379398
                    MOMENT*         2               400                                 1.0             *  4000N
                    *  4000N        0.0           124.8885574         0.0
                    FORCE*          1               500                                 1.0             *  5000M
                    *  5000M     70.60230249      0.0             -6685.78934577
                    MOMENT*         2               500                                 1.0             *  5000N
                    *  5000N        0.0           235.2506184         0.0
                    FORCE*          1               600                                 1.0             *  6000M
                    *  6000M     42.33434369      0.0             -2872.19975973
                    MOMENT*         2               600                                 1.0             *  6000N
                    *  6000N        0.0           224.6365418         0.0
                    FORCE*          1               700                                 1.0             *  7000M
                    *  7000M     59.41232873      0.0             -3344.87377537
                    MOMENT*         2               700                                 1.0             *  7000N
                    *  7000N        0.0           262.0759655         0.0
                    FORCE*          1               800                                 1.0             *  8000M
                    *  8000M     83.87946652      0.0             -4482.06723327
                    MOMENT*         2               800                                 1.0             *  8000N
                    *  8000N        0.0           336.9548127         0.0
                    FORCE*          1               900                                 1.0             *  9000M
                    *  9000M     61.30714759      0.0             -2573.72885512
                    MOMENT*         2               900                                 1.0             *  9000N
                    *  9000N        0.0            78.2259318         0.0
                    FORCE*          1               1000                                1.0             * 10000M
                    * 10000M     27.38244991      0.0            -11756.62817664
                    MOMENT*         2               1000                                1.0             * 10000N
                    * 10000N        0.0           202.1354482         0.0
                    FORCE*          1               1100                                1.0             * 11000M
                    * 11000M     23.12541991    103.21494745    5960.50952114
                    MOMENT*         2               1100                                1.0             * 11000N
                    * 11000N     -14.5761285    518.8725333        6.2085507
                    FORCE*          1               1200                                1.0             * 12000M
                    * 12000M   -113.48138880    368.30966802   18339.92339842
                    MOMENT*         2               1200                                1.0             * 12000N
                    * 12000N     -22.8769999    459.2326870        9.4854969
                    FORCE*          1               1300                                1.0             * 13000M
                    * 13000M   -167.47482007    479.82881212   16214.98538780
                    MOMENT*         2               1300                                1.0             * 13000N
                    * 13000N     -12.6374941    197.1100875        5.4498769
                    FORCE*          1               1400                                1.0             * 14000M
                    * 14000M    -81.06087995    457.28347940   14133.50024522
                    MOMENT*         2               1400                                1.0             * 14000N
                    * 14000N      -8.3753450     96.7618458        4.3561419
                    FORCE*          1               1500                                1.0             * 15000M
                    * 15000M    -33.41324906    106.98780051    4729.90095725
                    MOMENT*         2               1500                                1.0             * 15000N
                    * 15000N      -1.4133070     33.7559939        0.9256609
                    FORCE*          1               1600                                1.0             * 16000M
                    * 16000M     24.83744530    -20.57526086   -5010.13312244
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 10 OF 11)

```
LT.SAMPLE.DATA                                                          AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    13
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                          I N P U T   B U L K   D A T A   D E C K   E C H O

                          .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..   10  .
                          MOMENT*        2              1600                            1.0       * 16000N
                          * 16000N    -241.0580577      96.2258635   -9971.3569011
                          FORCE*         1              1700                            1.0       * 17000M
                          * 17000M     49.36181777    -16.45123705  -4784.14479814
                          MOMENT*        2              1700                            1.0       * 17000N
                          * 17000N    -229.2633806      91.8381949   -9968.4049129
                          FORCE*         1              1800                            1.0       * 18000M
                          * 18000M     13.79198437      0.0         -1886.26038382
                          MOMENT*        2              1800                            1.0       * 18000N
                          * 18000N      -0.0242191       5.9903734       0.0168548
                          FORCE*         1              1900                            1.0       * 19000M
                          * 19000M     -1.02852487      0.0          -116.10773109
                          MOMENT*        2              1900                            1.0       * 19000N
                          * 19000N       0.0             0.5615914       0.0
                          FORCE*         1              2000                            1.0       * 20000M
                          * 20000M     -3.30879590      0.0          -485.95650668
                          MOMENT*        2              2000                            1.0       * 20000N
                          * 20000N       0.0             1.8719712       0.0
                          FORCE1*         3              1102       10116.00000000       1800     *  1000P
                          *  1000P       1102
                          FORCE1*         3              1800       10116.00000000       1102     *  1000Q
                          *  1000Q       1800
                          FORCE1*         3               201        1565.50000000       1900     *  2000P
                          *  2000P        201
                          FORCE1*         3              1900        1565.50000000        201     *  2000Q
                          *  2000Q       1900
                          FORCE1*         3              1502         40531.463295       1502     * 28000D
                          * 28000D       1498
                          FORCE1*         3              1498         40531.463295       1498     * 28000E
                          * 28000E       1502
                          $
                          LOAD       10     1.0      1.0     1       1.0      2      1.0     3
                          $
                          $
                          $
                          ENDDATA

                          INPUT BULK DATA CARD COUNT =     536
```

FIGURE 2-12. MSC/NASTRAN INPUT BULK DATA DECK ECHO (SHEET 11 OF 11)

input data set, using the following NASTRAN elements.

- GRID points
- CBAR bar elements (with PBAR properties and MAT1 materials)
- RBAR rigid bar elements
- FORCE and MOMENT cards for applied loads

Although only a linear model is formed, the following KRASH85 nonlinearities are included in the NASTRAN model:

- Oleo beam elements (initial position must be fully extended)
- Unsymmetrical beam elements

A nonlinear KRASH model is acceptable (KR tables), as long as the initial conditions are in the linear region. The executive and case control decks, plus the bulk data deck, are all contained in date set XYZ.NASBLK.DATA, which is generated automatically by program KRASHIC.

2.3.2.4 Sorted Bulk Data Deck Echo

This is just an alphabetically sorted version of the bulk data deck shown in figure 2-12. The last page of this is shown in figure 2-13. The EPSILON value shown is a measure of the error in the static solution. Any value less than E-7 is acceptable. Generally speaking, any significant error in the model will result in a very large value for EPSILON (>0.1) or will cause the NASTRAN solution to terminate with an error message.

2.3.2.5 Displacement Vector

Figure 2-14 shows a sample of the displacement vector output. These data represent the desired solution. The three translations and rotations at each grid point in the NASTRAN model are shown. The sign convention for these displacements/rotations within the NASTRAN model is as follows:

T1	Positive deflection aft, inches
T2	Positive deflection right, inches

T3	Positive deflection up, inches
R1	Positive rotation left wing down, radians
R2	Positive rotation nose up, radians
R3	Positive rotation nose left, radians

All deflections/rotations are measured in an axis system that is parallel to the c.g. coordinate system defined in Section 2.2.

The grid point identifications within NASTRAN are related to the KRASH85 mass and mode points as follows:

Node point (I, M) becomes grid point (100*I + M) e.g. Node point 11, 2 becomes grid point 1102. Mass point 5 becomes grid point 500.

In figure 2-14, grid points 1199, 1498 and 1499 do not correspond to any node points in the KRASH model. In the KRASH model there are two transverse beams attached to mass 15 and one to mass 12; i.e., beams which connect laterally between mass 15 (and 12) and a phantom (unnumbered) point at the same location on the opposite side of the airplane. For these lateral beams, a grid point on the airplane plane of symmetry ($y = 0$) is established in the NASTRAN model in order to constrain the deflections of lateral beams. Grid points 1199, 1498, and 1499 are all such constrained grid points.

The deflections and rotations for grid point 500 (mass point 5) are all zero. This is because mass point 5 was specified by the user to be the constraint point in the model. This was done by inputting NBAL = 5 on card 60 of the input format (figure 2-3). This can be seen on card sequence number 90 in the input data echo for this sample case (figure 2-8).

2.3.2.6 Load Vector

Figure 2-15 shows the vector of applied loads for the sample case. These are the NASTRAN input net loads generated by KRASHIC in subroutine NETFOR. The sign convention for these loads is the same as for the displacements, as defined in the previous section. The loads shown for grid points 201, 1102, 1498 and 1502 are the result of using FORCE1 type cards in the

```
   LT.SAMPLE.DATA                                                           AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    23
    21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

    INITIAL CONDITION STATIC SOLUTION

                                                 S O R T E D   B U L K   D A T A   E C H O
                CARD
                COUNT        .   1  ..   2  ..   3  ..   4  ..   5  ..   6  ..   7  ..   8  ..   9  ..  10  .
                 451-        PBAR   *28000           28000           20.00000000     8000.00000000   * 28000A
                 452-        * 28000A1200.00000000   2700.00000000
                 453-        PLOTEL  201     200     201
                 454-        PLOTEL  501     500     501
                 455-        PLOTEL  1101    1100    1101
                 456-        PLOTEL  1102    1100    1102
                 457-        PLOTEL  1103    1100    1103
                 458-        PLOTEL  1201    1200    1201
                 459-        PLOTEL  1401    1400    1401
                 460-        PLOTEL  1501    1500    1501
                 461-        PLOTEL  1502    1500    1502
                 462-        PLOTEL  1601    1600    1601
                 463-        PLOTEL  1602    1600    1602
                 464-        PLOTEL  1701    1700    1701
                 465-        RBAR    201     200     201     123456                  123456
                 466-        RBAR    501     500     501     123456                  123456
                 467-        RBAR    1101    1100    1101    123456                  123456
                 468-        RBAR    1102    1100    1102    123456                  123456
                 469-        RBAR    1103    1100    1103    123456                  123456
                 470-        RBAR    1201    1200    1201    123456                  123456
                 471-        RBAR    1401    1400    1401    123456                  123456
                 472-        RBAR    1501    1500    1501    123456                  123456
                 473-        RBAR    1502    1500    1502    123456                  123456
                 474-        RBAR    1601    1600    1601    123456                  123456
                 475-        RBAR    1602    1600    1602    123456                  123456
                 476-        RBAR    1701    1700    1701    123456                  123456
                 477-        RBAR    24000   200     2100    123456                  123456
                             ENDDATA

                       TOTAL COUNT=   478




*** USER INFORMATION MESSAGE 3035 FOR DATA BLOCK KLL

   LOAD SEQ. NO.             EPSILON             STRAIN   ENERGY     EPSILONS LARGER THAN 0.001 ARE FLAGGED WITH ASTERISKS
               1         -1.1010772E-13          1.9329606E+05
```

FIGURE 2-13. MSC/NASTRAN SORTED BULK DATA DECK

```
LT.SAMPLE.DATA                                                    AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    24
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                         D I S P L A C E M E N T   V E C T O R

  POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
       100      G      -3.089143E-02   0.0           -9.927106E-01   0.0           -2.240265E-03   0.0
       200      G      -2.848941E-02   0.0           -7.668377E-01   0.0           -2.228401E-03   0.0
       201      G       1.302763E-01   0.0           -8.132805E-01   0.0           -2.228401E-03   0.0
       300      G      -7.956203E-03   0.0           -4.223564E-01   0.0           -2.016658E-03   0.0
       400      G      -3.881565E-03   0.0           -1.467094E-01   0.0           -1.310210E-03   0.0
       500      G       0.0            0.0            0.0            0.0            0.0            0.0
       501      G       0.0            0.0            0.0            0.0            0.0            0.0
       600      G       3.899802E-04   0.0           -1.395649E-01   0.0            1.905725E-03   0.0
       700      G      -1.741050E-02   0.0           -3.224221E-01   0.0            2.646156E-03   0.0
       800      G       1.960022E-02   0.0           -8.574673E-01   0.0            3.925506E-03   0.0
       900      G       1.623366E-01   0.0           -1.646018E+00   0.0            5.791202E-03   0.0
      1000      G       4.121324E-01   0.0           -2.947553E+00   0.0            6.380439E-03   0.0
      1100      G      -2.376698E-02  -6.204827E-02   4.549806E-01  -6.692734E-03  -2.201433E-03  -5.605535E-04
      1101      G      -1.923044E-02  -6.048078E-02   3.946607E-01  -6.692734E-03  -2.201433E-03  -5.605535E-04
      1102      G      -1.296102E-02  -1.657880E-01   7.333746E-01  -6.692734E-03  -2.201433E-03  -5.605535E-04
      1103      G      -1.296102E-02  -1.657880E-01   7.333746E-01  -6.692734E-03  -2.201433E-03  -5.605535E-04
      1199      G      -9.159946E-02   0.0            5.671601E-01   0.0           -6.671559E-03   0.0
      1200      G      -2.183176E-01   4.138304E-02   2.341775E+00  -1.306023E-02  -6.671559E-03  -9.325789E-04
      1201      G      -2.439480E-01   3.842933E-02   2.721844E+00  -1.306023E-02  -6.671559E-03  -9.325789E-04
      1300      G      -6.008078E-01   3.054584E-01   6.170222E+00  -2.241259E-02  -1.032131E-02  -1.681531E-03
      1400      G      -1.368588E+00   6.399867E-01   1.084582E+01  -2.562689E-02  -7.394198E-03  -5.296092E-03
      1401      G      -1.022665E+00   2.900504E-01   9.660528E+00  -2.562689E-02  -7.394198E-03  -5.296092E-03
      1498      G      -6.724794E-01   0.0            8.267691E+00   0.0           -9.067751E-03   0.0
      1499      G      -6.724794E-01   0.0            8.267691E+00   0.0           -9.067751E-03   0.0
      1500      G      -2.495204E+00   4.342735E-01   1.459584E+01  -1.709927E-02  -9.067751E-03  -4.925180E-03
      1501      G      -2.554648E+00   3.717274E-01   1.491737E+01  -1.709927E-02  -9.067751E-03  -4.925180E-03
      1502      G      -2.495204E+00   4.342735E-01   1.459584E+01  -1.709927E-02  -9.067751E-03  -4.925180E-03
      1600      G       7.919782E-02  -2.893808E-01   1.937816E+00  -1.295898E-02  -9.379067E-03  -1.573276E-03
      1601      G      -2.385539E-01   1.247806E-01   2.086101E+00  -1.295898E-02  -9.379067E-03  -1.573276E-03
      1602      G       7.919782E-02  -2.893808E-01   1.937816E+00  -1.295898E-02  -9.379067E-03  -1.573276E-03
      1700      G      -6.952541E-01  -3.463942E-02   8.834657E+00  -2.537073E-02  -9.936508E-03  -5.952671E-03
      1701      G      -1.014149E+00   6.997894E-01   8.967865E+00  -2.537073E-02  -9.936508E-03  -5.952671E-03
      1800      G       1.832867E-01  -7.628582E-01   6.224991E-01  -6.689236E-03  -2.204064E-03  -5.605265E-04
      1900      G       2.696309E-01   0.0           -8.798568E-01   0.0           -2.223161E-03   0.0
      2000      G      -9.809846E-02   0.0           -8.621072E-01   0.0           -4.137866E-03   0.0
      2100      G      -7.305723E-02   0.0           -7.669372E-01   0.0           -2.228401E-03   0.0
```

FIGURE 2-14. MSC/NASTRAN DISPLACEMENT VECTOR

```
LT.SAMPLE.DATA                                                          AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    25
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                                    L O A D   V E C T O R

  POINT ID.   TYPE         T1             T2              T3             R1             R2             R3
       100      G     -7.567860E+00   0.0            -7.223518E+02   0.0            7.487885E+01   0.0
       200      G     -3.155522E+01   0.0            -4.095044E+03   0.0            5.615913E+02   0.0
       201      G     -3.488073E+00   0.0             1.565496E+03   0.0            0.0            0.0
       300      G     -2.299168E+01   0.0            -6.531187E+03   0.0            1.814595E+02   0.0
       400      G      5.847729E+00   0.0            -4.032344E+03   0.0            1.248885E+02   0.0
       500      G      7.060229E+01   0.0            -6.685789E+03   0.0            2.352506E+02   0.0
       600      G      4.233434E+01   0.0            -2.872200E+03   0.0            2.246365E+02   0.0
       700      G      5.941232E+01   0.0            -3.344874E+03   0.0            2.620759E+02   0.0
       800      G      8.387946E+01   0.0            -4.482066E+03   0.0            3.369546E+02   0.0
       900      G      6.130714E+01   0.0            -2.573729E+03   0.0            7.822592E+01   0.0
      1000      G      2.738245E+01   0.0            -1.175662E+04   0.0            2.021354E+02   0.0
      1100      G      2.312541E+01   1.032149E+02    5.960508E+03  -1.457613E+01   5.188723E+02   6.208550E+00
      1102      G     -2.228247E+01   6.777931E+01    1.011575E+04   0.0            0.0            0.0
      1200      G     -1.134814E+02   3.683096E+02    1.833992E+04  -2.287700E+01   4.592327E+02   9.485497E+00
      1300      G     -1.674748E+02   4.798286E+02    1.621498E+04  -1.263749E+01   1.971101E+02   5.449877E+00
      1400      G     -8.106087E+01   4.572834E+02    1.413350E+04  -8.375344E+00   9.676184E+01   4.356141E+00
      1498      G      0.0           -4.053146E+04    0.0            0.0            0.0            0.0
      1500      G     -3.341324E+01   1.069878E+02    4.729898E+03  -1.413306E+00   3.375598E+01   9.256608E-01
      1502      G      0.0            4.053146E+04    0.0            0.0            0.0            0.0
      1600      G      2.483743E+01  -2.057526E+01   -5.010133E+03  -2.410580E+02   9.622586E+01  -9.971355E+03
      1700      G      4.936182E+01  -1.645123E+01   -4.784145E+03  -2.292634E+02   9.183818E+01  -9.968402E+03
      1800      G      3.607445E+01  -6.777931E+01   -1.200200E+04  -2.421910E-02   5.990373E+00   1.685480E-02
      1900      G      2.459549E+00   0.0            -1.681604E+03   0.0            5.615914E-01   0.0
      2000      G     -3.308795E+00   0.0            -4.859563E+02   0.0            1.871971E+00   0.0
```

FIGURE 2-15. MSC/NASTRAN LOAD VECTOR

NASTRAN input. These cards apply a constant axial force between two defined grid points. The FORCE1 cards in the sample case are used to account for nonlinear effects in oleos and unsymmetrical beams. There are no externally applied loads at node points, only at mass points.

2.3.2.7 Forces of Single-Point Constraint

Figure 2-16 shows the NASTRAN output that summarizes the forces of single-point constraint. This shows the forces and moments that are applied at the model constraint points to balance the model. For point 500, constraints are specified in all six directions, so corresponding forces are output. Note that the loads for the symmetric degrees of freedom (T1, T3, R2) are all very small, indicating that a well balanced set of applied loads is being used as input. This is the result of including inertia relief loads in the calculated net loads used as input to NASTRAN. The constraint forces in the anti-symmetric directions (T2, R1, R3) result from the geometry of the model. A half-airplane model is used, and wing loads come into mass 5. The constraint loads shown correspond to the missing loads that the right wing would have supplied. The same is true for grid points 600 and 900. Grid points 1199, 1498 and 1499 are center-plane grids as explained in Section 2.3.2.5. The single-point constraint forces shown for these grid points are the reactions at the center of transverse beams in the KRASH model.

2.3.2.8 Forces in Bar Elements

Figure 2-17 illustrates the NASTRAN output that summarizes the bar element static loads. The sign conventions for these loads are shown in figure 2-18, along with the corresponding KRASH85 beam element sign conventions. The KRASH85 loads that correspond to the NASTRAN bar element loads shown in figure 2-17 are as follows:

NASTRAN LOAD	CORRESPONDING KRASH85 LOAD
M1A	-MZI
M2A	MYI
M1B	MZJ
M2B	-MYJ
S1	FYJ
S2	FZJ
FX	FXJ
T	MXJ

NASTRAN plane 1 corresponds to the KRASH85 x-y plane, plane 2 corresponds to the x-z plane. Comparison of the loads in figure 2-17 with the KRASH "STRAIN FORCES" output at time zero will show a very close agreement. Beams which lie entirely in the airplane plane of symmetry (y = 0 plane) are treated differently in NASTRAN and KRASH85. In NASTRAN, the loads are for a half-beam, while in KRASH85 they are for an entire beam. This applies to beams 1000-9000, 19000 and 23000 in figure 2-17. (The NASTRAN bar element numbers are 1000 times the corresponding KRASH85 beam element numbers.) Beam 24000 is missing in the NASTRAN model; this is a DRI element which is modeled as a RBAR rigid element in NASTRAN.

2.3.2.9 Element Strain Energies

Figure 2-19 shows the NASTRAN output of bar element strain energies, in inch-pound units. Missing elements (1000, 25000, 26000) are those that have less than 0.001 percent of the total strain energy. These strain energies agree with the KRASH85 output at time zero, except for oleo and unsymmetrical beam elements. The use of FORCE1 cards in NASTRAN to model these nonlinear elements causes the strain energies calculated by NASTRAN to be incorrect. The KRASH85 strain energies for these elements are correct.

```
LT.SAMPLE.DATA                                                     AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83    PAGE     26
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                               F O R C E S   O F   S I N G L E - P O I N T   C O N S T R A I N T

  POINT ID.   TYPE          T1             T2             T3             R1             R2             R3
      500      G      9.535735E-06   1.102906E+05  -1.647945E-03   1.158149E+07   4.253135E-01  -2.487183E+06
      600      G      0.0           -2.197132E+04   0.0            1.765277E+06   0.0            1.538706E+06
      900      G      0.0            4.899299E+04   0.0            2.010931E+06   0.0            3.964869E+03
     1199      G      0.0           -6.197743E+04   0.0            9.611644E+05   0.0            7.206456E+05
     1498      G      0.0           -7.681350E+04   0.0            2.772235E+05   0.0            5.323329E+05
     1499      G      0.0            0.0            0.0            2.772235E+05   0.0            5.323329E+05
```

FIGURE 2-16. MSC/NASTRAN SINGLE-POINT CONSTRAINT FORCES

```
LT.SAMPLE.DATA                                                           AUGUST    3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    28
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                            F O R C E S   I N   B A R   E L E M E N T S         ( C B A R )

 ELEMENT        BEND-MOMENT END-A            BEND-MOMENT END-B                - SHEAR -               AXIAL
   ID.        PLANE 1       PLANE 2        PLANE 1       PLANE 2        PLANE 1       PLANE 2         FORCE         TORQUE
     1000    0.0          -7.487885E+01   0.0           7.289244E+04   0.0          -7.223914E+02  -1.141120E-01   0.0
     2000    0.0           7.469412E+04   0.0           9.423384E+05   0.0          -5.412238E+03  -2.830308E+02   0.0
     3000    0.0           9.421569E+05   0.0           2.854471E+06   0.0          -1.195028E+04  -1.146083E+02   0.0
     4000    0.0           2.854346E+06   0.0           6.051349E+06   0.0          -1.597832E+04  -3.910129E+02   0.0
     5000    0.0           8.780416E+06   0.0           6.951579E+06   0.0           1.301489E+04  -2.433165E+04   0.0
     6000    0.0           7.071534E+06   0.0           5.497074E+06   0.0           1.965147E+04  -2.519321E+04   0.0
     7000    0.0           5.496812E+06   0.0           3.567440E+06   0.0           1.199094E+04  -2.774932E+04   0.0
     8000    0.0           3.567104E+06   0.0           2.817684E+06   0.0           4.579750E+03  -2.801210E+04   0.0
     9000    0.0           2.474329E+06   0.0           2.020132E+02   0.0           1.154472E+04  -2.222242E+03   0.0
    10000   -3.186641E+06 -9.800311E+06   4.679865E+06 -3.733758E+06  -6.158012E+04 -4.748982E+04   8.985562E+04   6.447120E+06
    11000    5.434646E+06 -6.946986E+06   3.117507E+05 -3.193432E+06   2.957813E+04 -2.167194E+04   1.118354E+05   5.954459E+05
    12000    9.487483E+05 -4.564562E+06   2.698350E+06 -5.095244E+05  -9.511133E+03 -2.204386E+04   3.903610E+04  -3.209756E+05
    13000    2.677814E+06 -5.073569E+05   3.958839E+06  2.801262E+05  -6.911449E+03 -4.248664E+03   3.846765E+04  -4.644909E+05
    14000    4.043633E+06  6.632647E+05  -3.762905E+06  1.362978E+05   4.146377E+04  2.798940E+03   6.464662E+04   3.279091E+05
    15000    8.070355E+03  4.640827E+05   9.633930E+03  8.282319E+04  -2.054707E+01  5.010164E+03   1.699646E+01  -1.148579E+03
    16000    8.477410E+03  4.386772E+05   9.709035E+03  7.460462E+04  -1.618520E+01  4.784395E+03  -5.900237E+00  -3.062334E+03
    17000   -5.631099E+02 -4.264045E+02   1.222204E-02  2.995131E+00  -6.319184E+00 -4.818592E+00   1.161406E+04  -2.852223E-02
    18000   -5.631099E+02 -4.264045E+02   1.222204E-02  2.995131E+00  -6.319184E+00 -4.818592E+00   3.881768E+02  -2.852223E-02
    19000    0.0           8.109880E+01   0.0           5.615880E-01   0.0           1.287221E+00   1.681605E+03   0.0
    20000    1.520495E+06 -1.596292E+06  -5.776721E-01  6.527750E-01   5.198594E+03 -5.457746E+03  -2.170905E+04   7.988806E+05
    21000    3.323657E-11 -1.931766E+06  -1.521906E-09  9.507724E+05   2.346161E-12 -4.348730E+03   5.568998E+04   6.557260E+05
    22000   -7.206456E+05 -9.611644E+05  -7.206456E+05 -9.611643E+05   0.0          -9.094947E-13  -6.197740E+04   0.0
    23000    0.0           9.780161E+01   0.0          -1.871973E+00   0.0           5.007499E+00  -4.859414E+02   0.0
    25000    0.0           0.0            0.0           0.0            0.0           0.0            0.0            0.0
    26000    0.0           0.0            0.0           0.0            0.0           0.0            0.0            0.0
    27000   -5.323329E+05 -2.772235E+05  -5.323329E+05 -2.772234E+05  -1.080025E-12 -1.136868E-12   0.0            0.0
    28000   -5.323329E+05 -2.772235E+05  -5.323329E+05 -2.772234E+05  -1.080025E-12 -1.136868E-12  -1.173449E+05   0.0
```

FIGURE 2-17. MSC/NASTRAN BAR ELEMENT FORCES

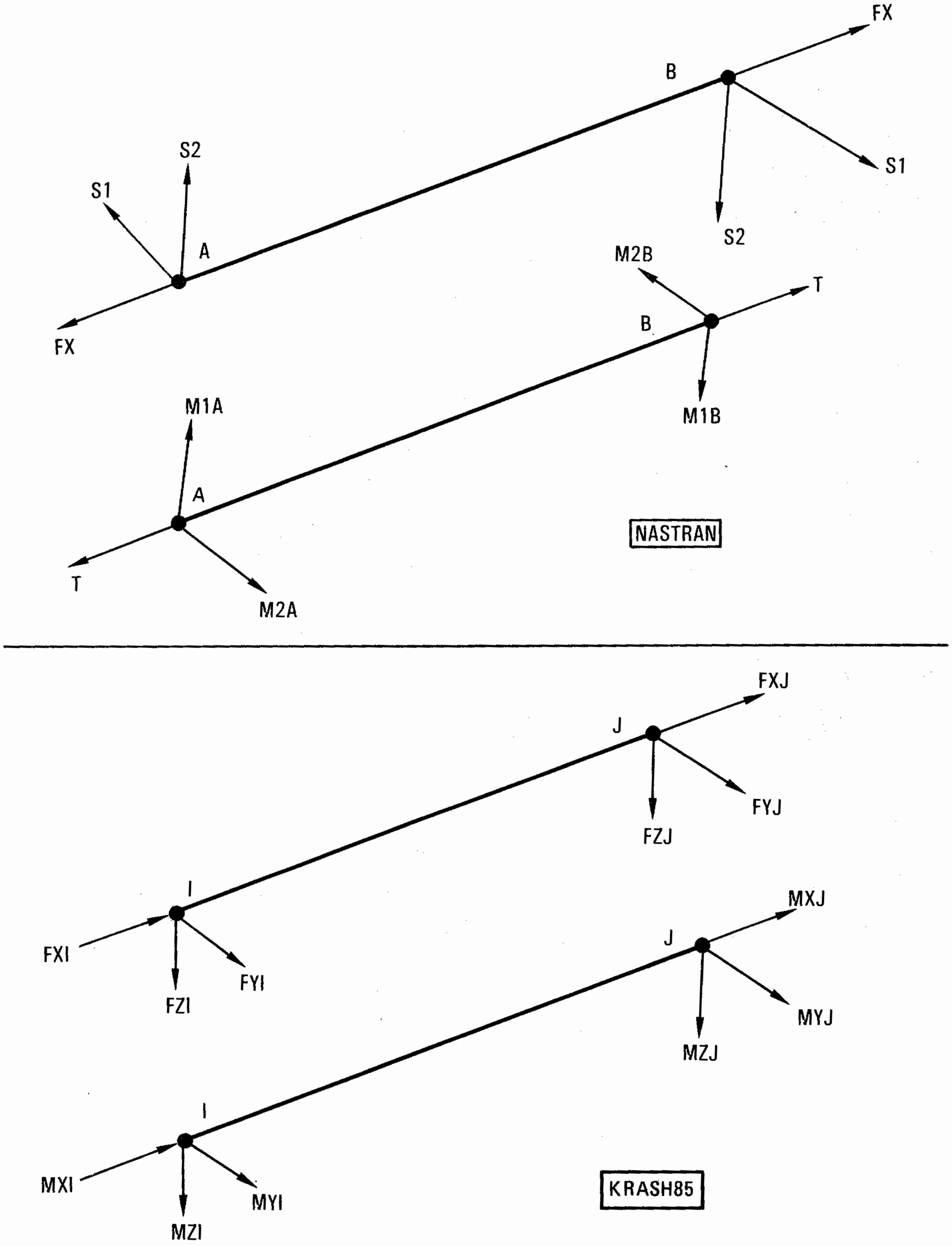


FIGURE 2-18. BAR ELEMENT FORCE SIGN CONVENTIONS, NASTRAN AND KRASH85

```
LT.SAMPLE.DATA                                                              AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83   PAGE    30
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                         E L E M E N T   S T R A I N   E N E R G I E S

            ELEMENT-TYPE = BAR                    * TOTAL ENERGY OF ALL ELEMENTS IN PROBLEM     =   1.932961E+05
            SUBCASE              1                  TOTAL ENERGY OF ALL ELEMENTS IN SET      -1 =   1.932961E+05
                                                                                           *
                              ELEMENT-ID          STRAIN-ENERGY           PERCENT OF TOTAL    STRAIN-ENERGY-DENSITY
                                    2000          6.693402E+01                0.0346              2.319581E-02
                                    3000          7.272415E+02                0.3762              2.524788E-01
                                    4000          3.042442E+03                1.5740              5.154527E-01
                                    5000          7.669977E+03                3.9680              1.850282E+00
                                    6000          2.427930E+03                1.2561              1.063298E+00
                                    7000          3.200997E+03                1.6560              8.289177E-01
                                    8000          3.338734E+03                1.7273              1.102878E+00
                                    9000          4.902207E+02                0.2536              1.829966E-01
                                   10000          3.545786E+04               18.3438              5.140170E+00
                                   11000          2.333120E+04               12.0702              2.131451E+00
                                   12000          1.634373E+04                8.4553              1.578104E+00
                                   13000          6.652102E+03                3.4414              8.818122E-01
                                   14000          1.038806E+04                5.3742              2.758766E+00
                                   15000          4.330408E+02                0.2240              7.113289E-01
                                   16000          3.841328E+02                0.1987              6.310025E-01
                                   17000          6.695837E+02                0.3464              2.511360E+01
                                   18000          2.238049E+01                0.0116              2.511472E+01
                                   19000          5.623860E+01                0.0291              1.714290E+01
                                   20000          1.203364E+04                6.2255              1.010890E+00
                                   21000          2.579918E+04               13.3470              9.563110E-01
                                   22000          7.894949E+03                4.0844              7.137922E-01
                                   23000          2.315073E+01                0.0120              1.142624E+01
                                   27000          3.681078E+03                1.9044
                                   28000          2.916098E+04               15.0862              1.969896E+00

                TYPE = BAR        SUBTOTAL        1.932961E+05              100.0000
```

FIGURE 2-19. MSC/NASTRAN ELEMENT STRAIN ENERGIES

2.3.2.10 Grid Point Force Balance

Figure 2-20 shows the NASTRAN output that tabulates all the forces and moments acting at the grid points. The totals shown at each grid point are not always zero; the loads due to RBAR rigid bar elements are not included in the balance. Therefore, mass points which have node points connected to them, as well as the corresponding node points, will show nonzero total loads. (Grid points 200 and 201 in figure 2-20 for example.) Mass points without node points (such as 500 or 600) will show zero total loads. Due to this anomaly in the grid point force balance output, these data are only marginally useful.

2.3.3 KRASH85 Output

2.3.3.1 Initial Output

The initial output of KRASH85 is identical to that of KRASHIC, described in Section 2.3.1. These data were illustrated in figures 2-8 through 2-10. The only exceptions to this are the mass and node point coordinates, as well as the initial mass and node point deflections. The values shown in the KRASHIC input represent the values before the last iteration of KRASHIC/ MSCTRAN. The values shown in the KRASH85 output are those following the last iteration. There will be slight differences in the deflections between those two outputs, unless a very large number of iterations are used (>10).

Figure 2-21 shows this section of the output from KRASH85. Note that the initial deflections and corresponding coordinate positions are slightly different from those shown in figure 2-9. As an example, the initial node point z deflection for node point 11, 1 changes from -.3946611 in figure 2-9 to -.3946607 in figure 2-21. These values represent before and after the tenth iteration. The corresponding node point z coordinates show no difference between figures 2-9 and 2-21, since the coordinate values are shown only to .001 inch. The differences are much finer than that.

Also, the initial deflections are in data set XYZ.NASOUT.DATA, which is always shown at the botton of the ECHO of input data. If all deflections in this data set agree between the KRASHIC and KRASH85 outputs, then further iterations cannot improve the accuracy of the initial conditions balance. If the two sets of data do differ, and the user is not satisfied with the quality of the initial balance, then further iterations could improve the initial balance.

KRASH85 includes some additional miscellaneous calculated data, in addition to that described for KRASHIC in Section 2.3.1.3. Figure 2-22 illustrates this output, which is calculated prior to time zero in KRASH85. These data include

- Beam uncoupled, undamped frequencies
- Beam damping constants
- Euler angles, beam IJ to airplane
- Load interaction curve load ratios (optional)

The beam frequencies output are the undamped, uncoupled individual beam frequencies associated with the six degrees of freedom of each beam. The frequencies listed under the headings (1), (2), and (3) correspond with the three translational degrees of freedom (x, y, z) and those listed under the heading (4), (5), and (6) correspond to the three rotational degrees of freedom (ϕ, θ, ψ). The frequencies are computed using equations 1-55(a) and 1-55(b) from Volume I, Section 1.3.5.3.6.

The frequency values summarized should be reviewed for indications of potential stability problems which may occur with the numerical integration routine used in the program. For example, high frequencies combined with a relatively coarse integration interval may result in numerical integration instabilities. In general, beam member frequencies should satisfy the following criteria:

1) Member frequencies < 500 Hz

2) The product of the maximum beam member frequency and the integration interval <0.01

```
LT.SAMPLE.DATA                                                              AUGUST   3, 1984  MSC/NASTRAN  8/ 1/83    PAGE    32
 21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

 INITIAL CONDITION STATIC SOLUTION

                                             G R I D   P O I N T   F O R C E   B A L A N C E

POINT-ID    ELEMENT-ID     SOURCE           T1            T2             T3            R1             R2            R3
    100                   APP-LOAD     -7.567860E+00  0.0           -7.223518E+02  0.0           7.487885E+01  0.0
    100          1000     BAR           7.567859E+00  0.0            7.223516E+02  0.0          -7.487885E+01  0.0
    100                   *TOTALS*     -1.546141E-11  0.0           -1.746230E-10  0.0          -1.536682E-08  0.0

    200                   APP-LOAD     -3.155522E+01  0.0           -4.095044E+03  0.0           5.615913E+02  0.0
    200          1000     BAR          -7.567859E+00  0.0           -7.223516E+02  0.0          -7.289244E+04  0.0
    200          2000     BAR           4.346039E+01  0.0            5.419457E+03  0.0           7.469412E+04  0.0
    200         23000     BAR          -3.308794E+00  0.0           -4.859561E+02  0.0          -9.780161E+01  0.0
    200                   *TOTALS*      1.028524E+00  0.0            1.161077E+02  0.0           2.265459E+03  0.0

    201                   APP-LOAD     -3.488073E+00  0.0            1.565496E+03  0.0           0.0           0.0
    201         19000     BAR           2.459548E+00  0.0           -1.681604E+03  0.0           8.109880E+01  0.0
    201                   *TOTALS*     -1.028524E+00  0.0           -1.161077E+02  0.0           8.109880E+01  0.0

    300                   APP-LOAD     -2.299168E+01  0.0           -6.531187E+03  0.0           1.814595E+02  0.0
    300          2000     BAR          -4.346039E+01  0.0           -5.419457E+03  0.0          -9.423384E+05  0.0
    300          3000     BAR           6.645207E+01  0.0            1.195064E+04  0.0           9.421569E+05  0.0
    300                   *TOTALS*     -1.421085E-12  0.0           -2.473826E-10  0.0           7.683411E-09  0.0

    400                   APP-LOAD      5.847729E+00  0.0           -4.032344E+03  0.0           1.248885E+02  0.0
    400          3000     BAR          -6.645207E+01  0.0           -1.195064E+04  0.0          -2.854471E+06  0.0
    400          4000     BAR           6.060435E+01  0.0            1.598299E+04  0.0           2.854346E+06  0.0
    400                   *TOTALS*      2.785328E-12  0.0           -1.164153E-10  0.0           1.024455E-08  0.0

    500                   F-OF-SPC      9.535735E-06  1.102906E+05  -1.647945E-03  1.158149E+07  4.253135E-01 -2.487183E+06
    500                   APP-LOAD      7.060229E+01  0.0           -6.685789E+03  0.0           2.352506E+02  0.0
    500          4000     BAR          -6.060435E+01  0.0           -1.598299E+04  0.0          -6.051349E+06  0.0
    500          5000     BAR          -2.312483E+04  0.0           -1.505520E+04  0.0           8.780416E+06  0.0
    500         10000     BAR           2.311484E+04 -1.102906E+05   3.772398E+04 -1.158149E+07 -2.729302E+06  2.487183E+06
    500                   *TOTALS*      1.546141E-11  1.455192E-11  -2.910383E-11 -6.984919E-10 -2.328306E-10 -1.396984E-09

    600                   APP-LOAD      4.233434E+01  0.0           -2.872200E+03  0.0           2.246365E+02  0.0
    600                   F-OF-SPC      0.0          -2.197132E+04   0.0           1.765277E+06  0.0           1.538706E+06
    600          5000     BAR           2.312483E+04  0.0            1.505520E+04  0.0          -6.951579E+06  0.0
    600          6000     BAR          -2.629875E+04  0.0           -1.814537E+04  0.0           7.071534E+06  0.0
    600         20000     BAR           3.131584E+03  2.197132E+04   5.962367E+03 -1.765277E+06 -1.201791E+05 -1.538706E+06
    600                   *TOTALS*     -3.365130E-11  4.547474E-12  -3.883542E-10 -2.328306E-10  2.124580E-08  0.0

    700                   APP-LOAD      5.941232E+01  0.0           -3.344874E+03  0.0           2.620759E+02  0.0
    700          6000     BAR           2.629875E+04  0.0            1.814537E+04  0.0          -5.497074E+06  0.0
    700          7000     BAR          -2.635816E+04  0.0           -1.480050E+04  0.0           5.496812E+06  0.0
    700                   *TOTALS*      5.820766E-11  0.0            1.527951E-09  0.0           3.725290E-09  0.0

    800                   APP-LOAD      8.387946E+01  0.0           -4.482066E+03  0.0           3.369546E+02  0.0
    800          7000     BAR           2.635816E+04  0.0            1.480050E+04  0.0          -3.567440E+06  0.0
    800          8000     BAR          -2.644204E+04  0.0           -1.031843E+04  0.0           3.567104E+06  0.0
    800                   *TOTALS*      1.455192E-11  0.0           -4.947651E-10  0.0           7.078052E-08  0.0

    900                   F-OF-SPC      0.0           4.899299E+04   0.0           2.010931E+06  0.0           3.964869E+03
    900                   APP-LOAD      6.130714E+01  0.0           -2.573729E+03  0.0           7.822592E+01  0.0
```

FIGURE 2-20. MSC/NASTRAN GRID POINT FORCE BALANCE

```
 2  1  -1.302763D-01   0.0           8.132805D-01

GENERALIZED SURFACE DATA

BETA =    0.0 DEGREES
XGIN =    0.0
ZGIN =    0.0


MASS DATA


        WEIGHTS           MASS COORDINATES F.S.,B.L.,W.L.          MASS MOMENTS OF INERTIA (LB-IN-SEC**2)

 I         W              X''             Y''             Z''            IX             IY             IZ           I
 1     1.58500D 03    1.98969D 02    0.0             2.19007D 02    1.15140D 04    4.00000D 04    1.50000D 04     1
 2     9.06450D 03    2.99972D 02    0.0             2.17933D 02    8.90800D 04    3.000000 05    9.90000D 04     2
 3     1.53181D 04    4.59992D 02    0.0             2.08278D 02    1.62780D 05    9.69350D 04    1.03090D 05     3
 4     1.30960D 04    6.19996D 02    0.0             2.05853D 02    1.96270D 05    6.67150D 04    7.93890D 04     4
 5     2.17526D 04    8.20000D 02    0.0             2.00200D 02    4.91060D 05    1.25670D 05    1.46510D 05     5
 6     7.90150D 03    9.60000D 02    0.0             2.12260D 02    8.13830D 04    1.20000D 05    2.00000D 05     6
 7     9.19070D 03    1.03998D 03    0.0             2.07578D 02    8.75360D 04    1.400000 05    2.00000D 05     7
 8     9.93840D 03    1.20002D 03    0.0             2.24243D 02    8.80980D 04    1.80000D 05    3.00000D 05     8
 9     5.70200D 03    1.36006D 03    0.0             2.58354D 02    9.62490D 04    4.17880D 04    2.60390D 04     9
10     6.17520D 03    1.57041D 03    0.0             2.99352D 02    2.15300D 05    1.07980D 05    1.58630D 05    10
11     9.67060D 03    8.01276D 02    1.18362D 02     1.887755D 02   1.52130D 04    1.38580D 05    3.60000D 05    11
12     1.00656D 04    8.52082D 02    2.71759D 02     2.05442D 02    1.95100D 04    1.22630D 05    3.00000D 05    12
13     5.28650D 03    9.42899D 02    4.30395D 02     2.26070D 02    7.27150D 03    5.26190D 04    1.10000D 05    13
14     3.75900D 03    1.04443D 03    5.82860D 02     2.54346D 02    4.40830D 03    2.58230D 04    6.00000D 04    14
15     1.54230D 03    1.11010D 03    7.40166D 02     2.69696D 02    1.67080D 03    9.01370D 03    1.800000 04    15
16     5.40000D 03    7.19079D 02    3.21889D 02     1.67738D 02    3.65156D 03    2.57460D 04    2.93746D 04    16
17     5.15100D 03    9.02105D 02    5.51635D 02     1.96935D 02    3.71200D 03    2.45882D 04    2.81780D 04    17
18     1.92200D 03    8.87183D 02    1.32363D 02     9.13225D 01    3.71000D 02    1.60000D 03    2.00000D 03    18
19     2.38000D 02    2.79270D 02    0.0             8.41201D 01    2.40000D 01    3.00000D 02    5.00000D 02    19
20     1.00000D 03    2.99902D 02    0.0             2.37838D 02    1.00000D 03    1.00000D 03    1.00000D 03    20
21     1.00000D 03    2.99927D 02    0.0             2.37933D 02    1.00000D 03    1.00000D 03    1.00000D 03    21


NODE POINT DATA

  MASS  N.P.     NODE POINT COORDINATES F.S.,B.L.,W.L.
    I    M         X''            Y''            Z''
    5    1     7.75100D 02    4.80000D 01    1.81000D D2
   11    1     7.73881D 02    1.18360D 02    1.86695D 02
   11    2     8.86987D 02    1.31766D 02    1.80433D 02
   11    3     8.86987D 02    1.31766D 02    1.80433D 02
   12    1     8.11556D 02    3.21562D 02    2.02322D 02
   14    1     9.93477D 02    5.51310D 02    2.30161D 02
   15    1     1.14545D 03    7.40228D 02    2.76217D 02
   15    2     1.11010D 03    7.40166D 02    2.69696D 02
   16    1     7.35461D 02    3.21475D 02    2.01686D 02
   16    2     7.19079D 02    3.21889D 02    1.67738D 02
   17    1     9.17386D 02    5.50900D 02    2.29468D 02
    2    1     2.79130D 02    0.0            1.46687D 02


:
EXTERNAL SPRING DATA
```

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 1 OF 2)

```
NO.MASS POSITION PLOTS

VEHICLE INITIAL CONDITIONS

VEHICLE TRANSLATIONAL VELOCITIES IN GROUND AXES (IN/SEC)
VEHICLE ROTATIONAL VELOCITIES IN VEHICLE AXES (RAD/SEC)
EULER ANGLES OF VEHICLE RELATIVE TO GROUND (RADIANS)

        XGDOT              YGDOT              ZGDOT
          P'                 Q'                 R'
         PHI'              THETA'              PSI'

      3.14000D 03        0.0                3.00000D 02
      0.0                1.00000D-01        0.0
      0.0                1.74500D-02        0.0

INITIAL MASS POINT DEFLECTIONS

 I      DXAP(I)        DYAP(I)          DZAP(I)        DPHAP(I)        DTHAP(I)        DPSAP(I)        I
 1    3.089143D-02   0.0             9.927106D-01   0.0             -2.240265D-03   0.0               1
 2    2.848941D-02   0.0             7.668377D-01   0.0             -2.228401D-03   0.0               2
 3    7.956203D-03   0.0             4.223564D-01   0.0             -2.016658D-03   0.0               3
 4    3.881565D-03   0.0             1.467094D-01   0.0             -1.310210D-03   0.0               4
 5    0.D            0.0             0.0            0.0              0.0            0.0               5
 6   -3.899802D-04   0.0             1.395649D-01   0.0              1.905725D-03   0.0               6
 7    1.741050D-D2   0.0             3.224221D-01   0.0              2.646156D-03   0.0               7
 8   -1.960022D-02   0.0             8.574673D-01   0.0              3.925506D-03   0.0               8
 9   -1.623366D-01   0.0             1.646018D 00   0.0              5.791202D-03   0.0               9
10   -4.121324D-01   0.0             2.947553D 00   0.0              6.380439D-03   0.0              10
11    2.376698D-02  -6.204827D-02  -4.549806D-01   6.692734D-03   -2.201433D-03   5.605535D-04     11
12    2.183176D-01   4.138304D-02  -2.341775D 00   1.306023D-02   -6.671559D-03   9.325789D-04     12
13    6.008078D-01   3.054584D-01  -6.170222D 00   2.241259D-02   -1.032131D-02   1.681531D-03     13
14    1.368588D 00   6.399867D-01  -1.084582D 01   2.562689D-02   -7.394198D-03   5.2960920-03     14
15    2.495204D 00   4.3427350-01  -1.459584D 01   1.709927D-02   -9.067751D-03   4.9251800-03     15
16   -7.919782D-02  -2.893808D-01  -1.937816D 00   1.295898D-02   -9.379067D-03   1.5732760-03     16
17    6.952541D-01  -3.463942D-02  -8.834657D 00   2.537073D-02   -9.936508D-03   5.9526710-03     17
18   -1.832867D-01  -7.628582D-01  -6.224991D-01   6.689236D-03   -2.204064D-03   5.605265D-04     18
19   -2.696309D-01   0.0             8.798568D-01   0.0             -2.223161D-03   0.0              19
20    9.809846D-02   0.0             8.621072D-01   0.0             -4.137866D-03   0.0              20
21    7.305723D-02   0.0             7.669372D-01   0.0             -2.228401D-03   0.0              21

INITIAL NODE POINT DEFLECTIONS

 I  M      DXNPAP          DYNPAP          DZNPAP
 5  1    0.0             0.0             0.0
11  1    1.923044D-02   -6.048078D-D2   -3.946607D-01
11  2    1.296102D-02   -1.657880D-01   -7.333746D-01
11  3    1.296102D-02   -1.657880D-01   -7.333746D-01
12  1    2.4394800-01    3.842933D-02   -2.721844D 00
14  1    1.022665D 00    2.900504D-01   -9.660528D 00
15  1    2.554648D 00    3.717274D-01   -1.491737D 01
15  2    2.495204D 00    4.342735D-01   -1.459584D 01
16  1    2.385539D-01    1.247806D-01   -2.086101D 00
16  2   -7.919782D-02   -2.893808D-01   -1.937816D 00
17  1    1.014149D 00    6.997894D-01   -8.967865D 00
```

FIGURE 2-21. KRASH85 OUTPUT, INITIAL MASS/NODE POINT DEFLECTIONS (SHEET 2 OF 2)

```
        -4.93617D 01   -1.64513D 01    4.78414D 03    2.29264D 02    9.18383D 01    9.96840D 03
        -9.34168D-03   -7.76185D-04    2.08112D-02   -2.21321D-04   -3.72978D-03   -2.38454D-04

18      -3.35372D 01    0.0            1.92171D D3    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         1.97453D 01    0.0           -3.54470D 01    2.42191D-02    5.99038D 00   -1.68548D-02
        -1.379190 01    0.0            1.88626D 03    2.42191D-02    5.99038D 00   -1.68548D-02
        -1.02326D-02    1.29277D-04    1.84649D-02   -2.09858D-06   -3.74386D-03    2.50486D-05

19      -4.15289D 00    0.0            2.37964D 02    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         6.20994D 00    0.0           -5.74830D 00    0.0            1.12318D 00    0.0
         2.05706D 00    0.0            2.32215D 02    0.0            1.12318D 00    0.0
        -2.60384D-D2    D.0            2.42105D-D2    0.0           -3.74395D-03    0.0

20      -1.74491D 01    0.0            9.99848D 02    0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            D.0            0.0            0.0            0.0
         2.40667D 01    0.0           -2.79347D 01    0.0            3.74395D 00    0.0
         6.61761D 00    0.0            9.71913D 02    0.0            3.74395D 00    0.0
        -2.39509D-02    0.0            2.80341D-02    0.0           -3.74395D-03    0.0

21       0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0
         0.0            0.0            0.0            0.0            0.0            0.0


BEAM UNCOUPLED,UNDAMPED FREQUENCIES (CPS)
 IJ  I  J  M  N     (1)         (2)         (3)         (4)         (5)         (6)
  1  1  2  0  0  1.5153D 02  1.7671D 02  2.2874D 02  9.6189D 01  1.3274D 02  1.6880D 02
  2  2  3  0  0  6.2094D 01  4.6372D 01  6.2054D 01  3.5380D 01  8.1503D 01  7.3325D 01
  3  3  4  0  0  5.5817D 01  4.1760D 01  5.9058D 01  2.9532D 01  1.1739D 02  7.7902D 01
  4  4  5  0  0  5.9388D 01  2.8866D 01  4.9366D 01  2.5029D 01  1.2571D 02  6.7576D 01
  5  5  6  0  0  8.4160D 01  5.8245D 01  9.1995D 01  3.9755D 01  1.1673D 02  6.2719D 01
  6  6  7  0  0  1.2795D 02  1.7495D 02  2.7023D 02  7.3988D 01  1.6315D 02  8.4980D 01
  7  7  8  0  0  7.8157D 01  6.0474D 01  8.2003D 01  4.8460D 01  9.5476D 01  5.7242D 01
  8  8  9  0  0  7.8113D 01  4.9757D 01  6.4332D 01  3.3242D 01  1.0111D 02  8.8339D 01
  9  9 10  0  0  6.2027D 01  1.9545D 01  6.0157D 01  2.6221D 01  1.1884D 02  4.2904D 01
 10  5 11  0  1  7.8575D 01  9.7901D 01  3.6562D 01  2.2297D 01  6.5550D 01  9.3224D 01
 11 11 12  1  D  8.5052D 01  6.8340D 01  2.2847D 01  1.6286D 01  5.7183D 01  6.0580D 01
 12 12 13  0  0  9.2917D 01  5.6161D 01  1.5987D 01  1.3332D 01  4.4400D 01  6.3168D 01
 13 13 14  0  0  9.8858D 01  4.1969D 01  1.2952D 01  1.3725D 01  3.8719D 01  5.4686D 01
 14 14 15  0  1  9.7455D 01  3.5862D 01  1.3889D 01  1.6384D 01  4.7736D 01  5.5927D 01
 15 12 16  1  1  5.5416D 01  8.9189D 00  2.4131D 01  9.6769D 00  2.1944D 01  7.2341D 00
 16 14 17  1  1  7.0474D 01  1.1343D 01  3.0688D 01  1.2004D 01  2.8512D 01  8.5438D 00
 17 11 18  2  0  4.5310D 00  2.7229D 01  2.7229D 01  1.5356D 01  7.1791D 01  1.5003D 02
 18 11 18  3  0  4.5310D 00  2.7229D 01  2.7229D 01  1.5356D 01  7.1791D 01  1.5003D D2
 19  2 19  1  0  1.4218D 01  4.4878D 01  4.4878D 01  6.6902D 00  7.2583D 01  2.5653D 02
 20  6 12  0  0  5.5440D 01  1.49150 01  4.6029D 00  5.3174D 00  1.6932D 01  2.4627D 01
 21  9 14  0  0  5.1478D 01  6.1110D 00  1.8859D 00  6.7777D 00  1.9219D 01  4.2045D 01
 22 12  0  0  0  3.8142D 01  5.5219D 00  1.7041D 00  3.7230D 00  1.9544D 01  1.6156D 01
 23  2 20  0  0  1.0537D 01  4.0643D 00  4.0643D 00  7.1706D-01  2.2599D 00  2.2688D 00
 24  2 21  0  0  8.4297D 00  4.0354D 00  4.0354D 00  7.1535D-01  2.2545D 00  2.2634D 00
 25 15 16  0  0  5.2941D 01  0.0         0.0         0.0         0.0         0.0
 26 15 16  2  2  5.2941D 01  0.0         0.0         0.0         0.0         0.0
```

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 1 OF 3)

```
 27 15  0  0  0  4.1389D 01  1.9371D 00  7.5022D-01  6.2405D 00  3.1341D 01  2.4668D 01
 28 15  0  2  0  4.1389D 01  1.9371D 00  7.5022D-01  6.2405D 00  3.1341D 01  2.4668D 01

DAMPING TERMS (LB/IN/SEC,TRANSLATIONS (1)-(3) AND LB-IN-SEC,ROTATIONS (4)-(6))
 IJ  I  J  M  N       (1)            (2)            (3)            (4)            (5)            (6)
  1  1  2  0  0    1.05034D-04    9.00681D-05    6.95787D-05    1.65461D-04    1.19896D-04    9.42867D-05
  2  2  3  0  0    2.56314D-04    3.43213D-04    2.56479D-04    4.49845D-04    1.95276D-04    2.17053D-04
  3  3  4  0  0    2.85135D-04    3.81116D-04    2.69490D-04    5.38921D-04    1.35583D-04    2.04302D-04
  4  4  5  0  0    2.67990D-04    5.51365D-04    3.22401D-04    6.35885D-04    1.26604D-04    2.35521D-04
  5  5  6  0  0    1.89111D-04    2.73250D-04    1.73004D-04    4.00342D-04    1.36345D-04    2.53759D-04
  6  6  7  0  0    1.24385D-04    9.09731D-05    5.88954D-05    2.15110D-04    9.75521D-05    1.87286D-04
  7  7  8  0  0    2.03635D-04    2.63177D-04    1.94085D-04    3.28423D-04    1.66696D-04    2.78039D-04
  8  8  9  0  0    2.03749D-04    3.19864D-04    2.47397D-04    4.78775D-04    1.57402D-04    1.80165D-04
  9  9 10  0  0    2.56589D-04    8.14317D-04    2.64566D-04    6.06964D-04    1.33923D-04    3.709560-04
 10  5 11  0  1    2.02552D-04    1.62567D-04    4.35297D-04    7.13786D-04    2.42798D-04    1.70722D-04
 11 11 12  1  0    1.87126D-04    2.32888D-04    6.96619D-04    9.77254D-04    2.78325D-04    2.62719D-04
 12 12 13  0  0    1.71287D-04    2.83388D-04    9.95514D-04    1.19376D-D3    3.58461D-04    2.51954D-04
 13 13 14  0  0    1.60993D-04    3.79222D-04    1.22882D-03    1.15964D-03    4.11048D-04    2.91034D-04
 14 14 15  0  1    1.63311D-04    4.43797D-04    1.14588D-03    9.71391D-04    3.33405D-04    2.84579D-04
 15 12 16  1  1    2.87200D-04    1.78447D-03    6.59558D-04    1.64468D-03    7.25262D-04    2.20006D-03
 16 14 17  1  1    2.25834D-04    1.40315D-03    5.18620D-04    1.32582D-03    5.58197D-04    1.86282D-03
 17 11 18  2  0    3.51261D-03    5.84496D-04    5.84496D-04    1.03643D-03    2.21691D-04    1.06081D-04
 18 11 18  3  0    3.51261D-03    5.84496D-04    5.84496D-04    1.03643D-03    2.21691D-04    1.06081D-04
 19  2 19  1  0    1.11938D-03    3.54641D-04    3.54641D-04    2.37893D-03    2.19272D-04    6.20421D-05
 20  6 12  0  D    2.87074D-04    1.06706D-03    3.45768D-03    2.99307D-03    9.39985D-04    6.46257D-04
 21  9 14  0  0    3.09170D-04    2.60439D-03    8.43919D-03    2.34821D-03    8.28098D-04    3.78532D-04
 22 12  0  0  0    4.17273D-04    2.88224D-03    9.33954D-03    4.27495D-03    8.14357D-04    9.85103D-04
 23  2 20  0  0    9.54928D-03    2.47574D-02    2.47574D-02    1.40327D-01    4.45248D-02    4.43507D-02
 24  2 21  0  0    8.75355D-03    1.82857D-02    1.82857D-02    1.03152D-01    3.27294D-02    3.260150-02
 25 15 16  0  0    3.00629D-04    0.0            0.0            0.0            0.0            0.0
 26 15 16  2  2    3.00629D-04    0.0            0.0            0.0            0.0            0.0
 27 15  0  0  0    3.84539D-04    8.21634D-03    2.12145D-02    2.55036D-03    5.07811D-04    6.45175D-04
 28 15  0  2  0    3.84539D-04    8.21634D-03    2.12145D-02    2.55036D-03    5.07811D-04    6.45175D-04

EULER ANGLES, BEAM IJ TO AIRPLANE (RADIANS)
 IJ  I  J  M  N     THEIJO(IJ)     PSIIJO(IJ)
  1  1  2  0  0   -1.06343D-02    3.14159D 00
  2  2  3  0  0   -6.02662D-02    3.14159D 00
  3  3  4  0  0   -1.51507D-02    3.14159D 00
  4  4  5  0  0   -2.82584D-02    3.14159D 00
  5  5  6  0  0    8.59336D-02    3.14159D 00
  6  6  7  0  0   -5.84820D-02    3.14159D 00
  7  7  8  0  0    1.03758D-01    3.14159D 00
  8  8  9  0  0    2.09997D-01    3.14159D 00
  9  9 10  0  0    1.92493D-01    3.14159D 00
 10  5 11  0  1   -1.05920D-01   -1.19924D 00
 11 11 12  1  0    1.08453D-01   -2.04225D 00
 12 12 13  0  0    1.12376D-01   -2.09074D 00
 13 13 14  0  0    1.53152D-01   -2.15829D 00
 14 14 15  0  1    1.16432D-01   -2.14145D 00
 15 12 16  1  1   -8.35444D-03    1.13479D-03
 16 14 17  1  1   -9.10265D-03    5.38477D-03
 17 11 18  2  0    2.20223D-03   -3.13489D 00
 18 11 18  3  0    2.20223D-03   -3.13489D 00
 19  2 19  1  0    2.22730D-03    3.14159D 00
 20  6 12  0  0   -2.33152D-02   -1.19278D 00
 21  9 14  0  0   -6.04694D-03   -1.07449D 00
 22 12  0  0  0    0.0            1.57080D 00
 23  2 20  0  0   -3.49710D-03    0.0
 24  2 21  0  0   -2.22840D-03    0.0
```

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 2 OF 3)

```
 25 15 16  0  0   -1.76219D-01     8.19057D-01
 26 15 16  2  2   -1.76219D-01     8.19057D-01
 27 15  0  0  0    0.0             1.57080D 00
 28 15  0  2  0    0.0             1.57080D 00

LOAD INTERACTION CURVE LOAD RATIOS

               PROPORTION OF BEAM END LOADS
CURVE  BEAM   MAKING UP INTERACTION LOADS
 NO.    NO.       I END        J END

  1      1    -2.8207D-04  1.0003D 00
  2      2     9.9982D-01  1.7804D-04
  3      2     3.7490D-01  6.2510D-01
  4      3     8.7495D-01  1.2505D-01
  5      3     4.9996D-01  5.0004D-01
  6      3    -2.4259D-05  1.0000D 00
  7      4     9.9998D-01  1.9407D-05
  8      5     2.7856D-06  1.0000D 00
  9      6     1.0000D 00 -4.8758D-06
 10      6     4.9989D-01  5.0011D-01
 11      7     7.4995D-01  2.5005D-01
 12      7     2.5006D-01  7.4994D-01
 13      8     7.5019D-01  2.4981D-01
 14      8     2.5032D-01  7.4968D-01
 15      9     8.1014D-01  1.8986D-01
```

FIGURE 2-22. KRASH85 OUTPUT, ADDITIONAL MISCELLANEOUS CALCULATED DATA (SHEET 3 OF 3)

While these criteria are suggested as guidelines, their exceedance does not necessarily mean that instability problems will automatically occur.

Beam structural damping coefficients are computed within the program for each of the six beam degrees of freedom. The damping coefficients are computed from equations (1-54), Section 1.3.5.3.6, Volume I.

These damping coefficients are printed only to provide a record of the actual data used in the calculations. The interpretation of the proper damping values should be based upon inspection of the damping ratios (actual damping/critical damping) summarized in the section entitled "INTERNAL BEAM DATA" (Section (2.3.3.2.2)). For typical aircraft constructions, damping ratios in the range of .01 to .10 are appropriate. Higher values should be used only to represent mechanical damping devices, such as hydraulic or friction dampers in landing gears or viscoelastic engine mounts. Values greater than .05 are probably only justified as representative of the friction damping associated with relative motions of riveted and bolted structure under conditions of severe loading and deformation.

The Euler angles define the initial orientation of the beam axes relative to the airplane, according to the convention shown in figure 2-5. These angles should be interpreted in the following manner. Assume the beam axes are oriented such that x is forward, y to the right and z down. Then rotate PSIIJO radians about the z axis, positive nose right, forming a new set of x' and y' axes. Then rotate THEIJO radians about the new y' axis, positive nose up. This final position defines the orientation of the beam axes with respect to the airplane. For vertical beams, which are denoted by VBM=1 in the beam data formatted output, the above procedure is followed with one exception. The initial orientation is such that the x axis is positive up, y axis positive right and z axis positive forward.

It should be noted that during the time history analysis, these angles vary with time and are part of the print output. Any question regarding the current beam orientations should be resolved by examining the current values of the beam orientation Euler angles. These are interpreted the same as the preceding discussion, except that the initial starting orientation is the ground axes rather than the airplane axes. Since the initial attitude of the vehicle may not be parallel to the ground axes (generally it is not), the time zero value of the beam orientation Euler angles may differ from the angles listed in the MODEL PARAMETERS section of the output. The latter is provided as a definition of beam axes orientations that is independent of vehicle initial conditions (and hence represents a true model parameter), whereas the time varying values represent the actual beam orientation during the analysis.

The load interaction curve load ratios tabulate what proportion of the I and J end beam loads are used to calculate the intermediate loads at the location specified for each load interaction curve.

2.3.3.2 Time History Output

This section of the output prints the time varying response quantities at each print time interval, including time zero. This output consists of the following groups of data:

- Title cards
- Analysis time
- Mass and node point displacements, velocities and accelerations in six directions for all NM lumped masses and NNP node points, in mass axes and ground axes
- Mass impulses (G-sec) based on filtered accelerations
- Internal beam strain forces, total forces (strain + damping) in both beam and mass axes and displacements in six directions for all NB internal beams
- External spring compressions, ground deflections, axial loads, and ground contact loads (3 directions) in ground axes and mass axes for all NSP external springs
- DRI number for all DRI beam elements
- Overall vehicle c.g. translational velocity (3 directions)
- Volume change data, including current volume, current volume/initial volume, and the changes in length of the three lengths of the volume (optional)

- Energy distribution by type

- Energy distribution by mass (mass deviation, kinetic, potential, external work), by beam (strain, damping) and by spring (crushing, friction)

- Stress output for internal beam elements, including ratios of current stress/failure stress for two failure theories

- At t=0 only, the differences between actual initial mass accelerations and the theoretically exact values, for all NM masses.

- Mass location plot (time=0 and at specified intervals)

Figure 2-23 illustrates a portion of this output for the sample case, for one typical cut in time. It should be noted that all this output is in inch, pound, second and radian units except XACCEL, YACCEL and ZACCEL. These are in g's. A more detailed description of the specific items printed out at each time follows.

2.3.3.2.1 Mass and Node Point Data

X, Y and Z are the ground coordinates of mass I or node point I, M. The data for each node point are printed below the data for the mass to which they are attached. XDOT, YDOT and ZDOT are the ground axes components of the translational velocity of mass I or node point I, M. U, V and W are the corresponding components in mass fixed axes. UDOT, VDOT and WDOT (not printed for the node points) are the time derivatives of U, V and W. Note that these are not the translational acceleration components, but are used in Euler's equations of motion. XACCEL, YZCCEL and ZACCEL are the body-fixed-axes components of the translational accelerations of mass I or node point I, M, in g units. XACFIL, YACFIL and ZACFIL are the same accelerations after passing through a first order filter with an input cutoff frequency. All the above quantities are positive forward, right and down.

PHI, THETA and PSI are the Euler angles defining the orientations of mass I with respect to the ground. These are positive right-wing-down, nose-up and nose-right, respectively. PHIDOT, THETADOT and PSIDOT are the time derivatives of the same angles. P, Q and R are the body axes components of the angular

```
LT.SAMPLE.DATA                                                                   SUBROUTINE PRINT
21 MASS/28 BEAM TEST CASE ONLY-NOT VALID AIRPLANE MODEL

TIME = 0.050000     NUMBER OF INTEGRATION INTERVALS = 200

                  X           Y                Z           PHI           THETA       PSI
                XDOT        YDOT             ZDOT        PHIDOT        THETADOT    PSIDOT
                  U           V                W            P              Q          R
                UDOT        VDOT             WDOT         PDOT           QDOT       RDOT
               XACCEL      YACCEL           ZACCEL       XACFIL         YACFIL     ZACFIL

MASS    1    8.00733D+02   0.0           -1.47442D+02   0.0           1.99344D-02   0.0
             3.12727D+03   0.0            2.42624D+02   0.0           4.22119D-02   0.0
             3.12181D+03   0.0            3.04912D+02   0.0           4.22119D-02   0.0
            -8.02949D+02   0.0            3.04496D+02   0.0          -2.25875D+00   0.0
            -2.04683D+00   0.0            4.47458D-01  -2.09190D+00   0.0           5.90161D-01

MASS    2    6.99778D+02   0.0           -1.44129D+02   0.0           1.99257D-02   0.0
             3.12748D+03   0.0            2.47309D+02   0.0           5.09838D-02   0.0
             3.12193D+03   0.0            3.09573D+02   0.0           5.09838D-02   0.0
            -7.89331D+02   0.0            1.16745D+02   0.0          -1.99715D+00   0.0
            -2.00401D+00   0.0           -1.09904D-01  -2.06380D+00   0.0          -3.36354D-01

  NODE 1     7.22192D+02   0.0           -7.33622D+01
             3.13109D+03   0.0            2.46166D+02
             3.12556D+03   0.0            3.08503D+02
            -2.37254D+00   0.0           -1.73045D-03  -2.59084D+00   0.0          -1.81653D-01

MASS    3    5.40001D+02   0.0           -1.30965D+02   0.0           1.95106D-02   0.0
             3.12910D+03   0.0            2.57322D+02   0.0           6.14073D-02   0.0
             3.12348D+03   0.0            3.18320D+02   0.0           6.14073D-02   0.0
            -6.44913D+02   0.0           -2.40676D+02   0.0          -3.72644D+00   0.0
            -1.62012D+00   0.0           -1.12042D+00  -1.70710D+00   0.0          -9.77881D-01

MASS    4    3.80066D+02   0.0           -1.25204D+02   0.0           1.87936D-02   0.0
             3.13064D+03   0.0            2.61274D+02   0.0          -1.53279D-02   0,0
             3.12517D+03   0.0            3.20060D+02   0.0          -1.53279D-02   0.0
            -3.67004D+02   0.0           -1.34866D+03   0.0          -4.68098D+00   0.0
            -9.63497D-01   0.0           -3.36983D+00  -1.00582D+00   0.0          -2.20052D+00

MASS    5    1.80194D+02   0.0           -1.15644D+02   0.0           1.90969D-02   0.0
             3.13157D+03   0.0            2.54926D+02   0.0          -2.63228D-02   0.0
             3.12613D+03   0.0            3.14679D+02   0.0          -2.63228D-02   0.0
            -1.21744D+02   0.0           -1.88046D+03   0.0           6.69797D-01   0.0
            -3.36859D-01   0.0           -4.65848D+00  -4.37244D-01   0.0          -3.73706D+00

  NODE 1     2.25452D+02  -4.80000D+01   -9.73046D+01
             3.13108D+03   0.0            2.56118D+02
             3.12562D+03   0.0            3.15861D+02
            -3.03624D-01   0.0           -4.73642D+00  -4.46573D-01   0.0          -3.71546D+00

MASS    6    3.99989D+01   0.0           -1.24717D+02   0.0           2.50095D-02   0.0
             3.13100D+03   0.0            2.60638D+02   0.0           9.10640D-02   0.0
             3.12351D+03   0.0            3.38853D+02   0.0           9.10640D-02   0.0
            -2.97959D+02   0.0           -1.18410D+03   0.0           3.48009D+00   0.0
            -6.91974D-01   0.0           -3.80452D+00  -8.22832D-01   0.0          -3.03332D+00

MASS    7   -3.98394D+01   0.0           -1.18139D+02   0.0           2.68814D-02   0.0
             3.13128D+03   0.0            2.68794D+02   0.0           1.09835D-01   0.0
             3.12292D+03   0.0            3.52859D+02   0.0           1.09835D-01   0.0
```

Figure 2-23. KRASH85 Time History Output (Sheet 1 of 10)

```
             -3.82724D+02    0.0            -9.35406D+02    0.0             9.95332D-01    0.0
             -8.91109D-01    0.0            -3.31195D+00   -1.05350D+00    0.0           -2.87460D+00

MASS    8    -2.00215D+02    0.0            -1.30811D+02    0.0             2.91838D-02    0.0
              3.12917D+03    0.0             2.89501D+02    0.0             1.49132D-01    0.0
              3.11939D+03    0.0             3.80686D+02    0.0             1.49132D-01    0.0
             -4.00579D+02    0.0            -1.67921D+03    0.0            -1.05738D+01    0.0
             -8.90690D-01    0.0            -5.55546D+00   -1.13965D+00    0.0           -5.73758D+00

MASS    9    -3.61024D+02    0.0            -1.60932D+02    0.0             2.99974D-02    0.0
              3.12268D+03    0.0             3.23403D+02    0.0             2.68325D-01    0.0
              3.11157D+03    0.0             4.16916D+02    0.0             2.68325D-01    0.0
             -4.44553D+02    0.0            -2.12799D+03    0.0             5.15930D+00    0.0
             -8.61876D-01    0.0            -7.67593D+00   -1.33887D+00    0.0           -7.12323D+00

MASS   10    -5.72270D+02    0.0            -1.96934D+02    0.0             2.96380D-02    0.0
              3.11050D+03    0.0             3.86175D+02    0.0             3.15401D-01    0.0
              3.09769D+03    0.0             4.78181D+02    0.0             3.15401D-01    0.0
             -1.46931D+03    0.0             1.38235D+03    0.0             2.62217D+01    0.0
             -3.41578D+00    0.0             1.05009D+00   -3.83348D+00    0.0            1.42682D+00

MASS   11     1.99035D+02   -1.18350D+02    -1.04812D+02    7.37477D-03   -7.02829D-04    5.49534D-04
              3.13039D+03   -2.05086D-01     2.41494D+02    6.02189D-02   -4.80804D-01    1.21820D-02
              3.13056D+03   -1.60571D-01     2.39301D+02    6.02271D-02   -4.80701D-01    1.57274D-02
              1.22826D+02   -9.36459D+01    -3.41354D+03    1.35749D+00    2.73027D+00    8.04503D-01
              2.01973D-02   -1.52391D-01    -4.94477D+00   -1.45852D-01   -3.04424D-01   -5.59127D+00

   NODE 1     2.26434D+02   -1.18350D+02    -1.02792D+02
              3.12942D+03    7.71139D-03     2.54666D+02
              3.12960D+03    1.49902D-01     2.52472D+02
              1.79298D-02   -1.04412D-01    -5.13973D+00   -1.70875D-01   -2.56522D-01   -5.46953D+00

   NODE 2     1.13337D+02   -1.31759D+02    -9.63707D+01
              3.12650D+03   -1.76322D+00     1.99481D+02
              3.12664D+03   -2.02633D+00     1.97304D+02
              1.61117D-01   -3.54856D-01    -4.39054D+00   -9.49895D-02   -6.76758D-01   -6.17975D+00

   NODE 3     1.13337D+02   -1.31759D+02    -9.63707D+01
              3.12650D+03   -1.76322D+00     1.99481D+02
              3.12664D+03   -2.02633D+00     1.97304D+02
              1.61117D-01   -3.54856D-01    -4.39054D+00   -9.49895D-02   -6.76758D-01   -6.17975D+00

MASS   12     1.48075D+02   -2.71777D+02    -1.20343D+02    6.52104D-03    5.80848D-03    6.55330D-04
              3.13390D+03   -5.13975D-01     2.47087D+02   -3.42235D-01   -3.90598D-01   -5.08267D-02
              3.13241D+03   -8.37741D-01     2.65297D+02   -3.41940D-01   -3.90922D-01   -4.82777D-02
             -1.81797D+02    3.33043D+01    -3.05038D+03   -5.03217D+00    5.78855D+00   -2.78704D+00
             -7.39762D-01   -7.04807D-02    -4.72944D+00   -8.31293D-01   -1.67634D-01   -4.40509D+00

   NODE 1     1.88624D+02   -3.21572D+02    -1.17403D+02
              3.13032D+03   -1.48884D+00     2.79963D+02
              3.12864D+03   -1.59599D+00     2.98158D+02
             -1.08021D+00   -2.87681D-01    -4.69071D+00   -1.39422D+00   -4.53741D-01   -2.67885D+00

MASS   13     5.68609D+01   -4.30516D+02    -1.38101D+02    1.46830D-02    9.56579D-03    9.94484D-04
              3.13233D+03   -2.66183D+00     2.78435D+02   -3.30597D-01   -1.12590D-01   -3.29210D-02
              3.12952D+03   -1.24841D+00     3.08437D+02   -3.30282D-01   -1.13062D-01   -3.12629D-02
             -7.19869D+02    1.41326D+02    -2.52929D+03   -4.44226D+00   -1.32357D+01   -2.11945D+00
             -1.95539D+00    3.76579D-01    -5.63484D+00   -1.70503D+00    1.96307D-01   -5.68715D+00

MASS   14    -4.53884D+01   -5.82934D+02    -1.63826D+02    2.52866D-02    1.44151D-02    4.13715D-03
```

Figure 2-23. KRASH85 Time History Output (Sheet 2 of 10)

```
              3.12414D+03  -4.20850D+00   3.25967D+02  -1.54595D-01   4.14392D-02  -7.59634D-02
              3.11908D+03  -7.74854D+00   3.71280D+02  -1.53500D-01   3.95055D-02  -7.69789D-02
             -9.17815D+02  -2.01055D+01   2.34643D+02  -1.52954D+01  -4.72061D+00  -1.26274D+00
             -2.34131D+00  -5.26469D-01   2.91741D-01  -1.99935D+00  -6.86124D-01   4.86456D-01

    NODE 1    6.11726D+00  -5.51433D+02  -1.40772D+02
              3.12741D+03  -4.43868D+00   3.18991D+02
              3.12244D+03  -8.16732D+00   3.64360D+02
             -2.51906D+00   2.13571D-01  -3.44325D-01  -2.04551D+00  -9.32978D-02  -2.38063D-01

MASS   15    -1.11481D+02  -7.40176D+02  -1.77794D+02   1.77534D-02   1.34372D-02   4.67595D-05
              3.11651D+03  -6.43964D-01   3.25578D+02   7.86644D-02   7.82878D-02  -2.52689D-02
              3.11181D+03  -8.69145D+00   3.67636D+02   7.90039D-02   7.78269D-02  -2.66525D-02
             -1.05577D+03  -1.23405D+02   5.21903D+02   3.27103D+00  -4.75941D+00  -1.46144D-01
             -2.66163D+00  -6.09812D-01   7.22885D-01  -2.38896D+00  -5.68084D-01   3.61200D-01

    NODE 1   -1.46960D+02  -7.40226D+02  -1.83518D+02
              3.11606D+03   7.38215D-01   3.28364D+02
              3.11133D+03  -7.25803D+00   3.70391D+02
             -2.58451D+00  -5.44385D-01   2.86861D-01  -2.33163D+00  -4.51933D-01   3.90864D-02

    NODE 2   -1.11481D+02  -7.40176D+02  -1.77794D+02
              3.11651D+03  -6.43963D-01   3.25578D+02
              3.11181D+03  -8.69145D+00   3.67636D+02
             -2.66163D+00  -6.09812D-01   7.22885D-01  -2.38896D+00  -5.68084D-01   3.61200D-01

MASS   16     2.81845D+02  -3.21872D+02  -8.45587D+01  -7.57106D-02   4.69176D-02   5.40620D-02
              3.13459D+03   1.43295D+00   2.96776D+02  -8.00398D-02   9.60627D-02  -3.57953D-02
              3.11273D+03  -2.00995D+02   4.29279D+02  -7.85610D-02   9.84920D-02  -2.83874D-02
             -3.63575D+02   2.18711D+01   1.15656D+03  -1.45165D+01  -7.03124D+00  -1.13756D+00
             -8.47152D-01  -8.51099D-02   2.24284D+00  -7.21388D-01  -4.95147D-02   2.46003D+00

    NODE 1    2.64721D+02  -3.21524D+02  -1.18140D+02
              3.13153D+03  -8.73608D-01   2.98315D+02
              3.10947D+03  -2.03231D+02   4.30501D+02
             -2.13538D-01  -1.32329D+00   1.81659D+00  -7.53959D-01  -5.36276D-01   2.42082D+00

    NODE 2    2.81845D+02  -3.21872D+02  -8.45587D+01
              3.13459D+03   1.43295D+00   2.96776D+02
              3.11273D+03  -2.00995D+02   4.29279D+02
             -8.47152D-01  -8.51099D-02   2.24284D+00  -7.21388D-01  -4.95147D-02   2.46003D+00

MASS   17     9.82658D+01  -5.51659D+02  -1.09650D+02  -6.29956D-02   4.74938D-02   6.00626D-02
              3.13561D+03  -1.95470D+00   3.09650D+02  -1.00923D-01   2.19182D-01   5.31815D-02
              3.11161D+03  -2.18620D+02   4.45013D+02  -1.03448D-01   2.15404D-01   6.68145D-02
             -9.80846D+02  -2.50529D+02   5.69162D+02   4.47852D-01   4.58501D+00   1.19771D+00
             -2.25487D+00   8.82878D-03  -2.03301D-01  -1.45300D+00  -9.17253D-02   1.88957D-01

    NODE 1    8.22150D+01  -5.51003D+02  -1.41812D+02
              3.12873D+03  -6.54476D+00   3.12990D+02
              3.10432D+03  -2.22969D+02   4.47742D+02
             -2.65266D+00   1.45979D-03  -2.22962D-02  -1.90516D+00  -1.79250D-01   3.84174D-01

MASS   18     1.11241D+02  -1.32428D+02  -1.48176D+01   8.69037D-03  -3.81786D-02   1.21343D-04
              3.13098D+03   1.51656D+01  -1.09811D+01  -2.86730D-01   2.42900D-01   9.42867D-03
              3.12828D+03   1.36513D+01  -1.30605D+02  -2.86370D-01   2.42972D-01   7.31058D-03
              1.09036D+04   4.17790D+02   1.65221D+04  -9.44075D+00   1.83091D+02   2.39093D+00
              2.81652D+01   1.04471D+00   4.08242D+01   2.81838D+01   2.51584D+00   2.63642D+01

MASS   19     7.22352D+02   0.0          -1.21246D+01   0.0          -7.80386D-03   0.0
```

Figure 2-23. KRASH85 Time History Output (Sheet 3 of 10)

```
  3   4   0   0   3.6859D+04   0.0         -5.3163D+03   0.0         -4.3550D+06   3.5045D+06   0.0          0.0
  4   5   0   0   4.7638D+04   0.0         -5.8597D+04   0.0         -3.8168D+06  -7.9078D+06   0.0          0.0
  5   6   0   0  -1.7861D+05   0.0          1.7177D+05   0.0          6.1010D+07  -3.6874D+07   0.0          0.0
  6   7   0   0  -1.2353D+05   0.0          1.6815D+05   0.0          3.8531D+07  -2.5059D+07   0.0          0.0
  7   8   0   0  -1.3706D+05   0.0          1.0990D+05   0.0          2.5199D+07  -7.5170D+06   0.0          0.0
  8   9   0   0  -1.2589D+05   0.0          3.3667D+04   0.0          5.6138D+06  -1.0533D+05   0.0          0.0
  9  10   0   0  -2.3878D+04   0.0          1.2675D+04   0.0         -1.1504D+05   2.8314D+06   0.0          0.0
  5  11   0   1  -5.1516D+04  -1.0715D+05  -1.7360D+05   3.0523D+07  -1.0643D+07  -1.1531D+07   2.1668D+07  -7.9799D+06
 11  12   1   0   8.5379D+03  -6.4370D+03   3.0817D+04  -3.0110D+06   5.2422D+06   9.4722D+04   3.5472D+06  -2.4328D+06
 12  13   0   0  -4.7185D+03  -1.4612D+04   1.7867D+03  -1.5679D+06  -1.1445D+06   1.4730D+06   2.8275D+06  -1.3966D+05
 13  14   0   0   2.1134D+03  -2.4449D+04  -1.1482D+04  -1.0341D+06  -1.7252D+06  -4.0297D+05   3.5712D+05   4.1744D+06
 14  15   0   1   5.9498D+04   4.2977D+04   1.3996D+03   2.5312D+05   4.9538D+05  -2.3186D+05  -4.5243D+06  -3.5671D+06
 12  16   1   1   4.0781D+03  -3.2687D+02  -7.1406D+03   5.5518D+04  -9.9059D+05   4.4712D+05   4.4515D+03   2.0426D+04
 14  17   1   1   1.1547D+04   7.7256D+02   5.5300D+03  -2.0099D+04   2.5324D+05   1.6760D+05  -6.9226D+04   1.0438D+04
 11  18   2   0  -2.4626D+05   1.8193D+03  -5.4299D+04  -2.4402D+03  -5.2900D+06   5.7359D+05  -1.8431D+05   1.4894D+04
 11  18   3   0  -2.9907D+01   1.8193D+03  -5.4299D+04  -2.4402D+03  -5.2900D+06   5.7359D+05  -1.8431D+05   1.4894D+04
  2  19   1   0  -3.6894D+04   0.0         -9.9288D+03   0.0         -7.4520D+05   1.3176D+05   0.0          0.0
  6  12   0   0   1.8279D+04   5.7127D+03  -5.3578D+03   1.3232D+06  -1.5671D+06   0.0         -1.6709D+06   0.0
  9  14   0   0   9.4547D+04   0.0         -4.1329D+03   7.1606D+05  -1.7802D+06  -9.5926D+05   0.0          0.0
 12   0   0   0  -3.3977D+04   0.0          0.0          0.0         -3.5193D+05   3.5193D+05   4.3108D+05  -4.3108D+05
  2  20   0   0  -9.3972D+02   0.0          5.2880D+02   0.0          5.3233D+03   5.2131D+03   0.0          0.0
  2  21   0   0  -1.3586D+03   0.0          4.1932D+02   0.0          4.0772D+03   4.2378D+03   0.0          0.0
 15  16   0   0   0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
 15  16   2   2   0.0          0.0          0.0          0.0          0.0          0.0          0.0          0.0
 15   0   0   0   0.0          0.0          0.0          0.0         -2.9991D+05   2.9991D+05   4.9331D+05  -4.9331D+05
 15   0   2   0  -7.4156D+04   0.0          0.0          0.0         -2.9991D+05   2.9991D+05   4.9331D+05  -4.9331D+05


COMPONENTS OF TOTAL BEAM FORCES ACTING ON MASSES I AND J
LOADS ARE THOSE ACTING ON THE MASS, IN MASS AXES, +FWD,RT,DN
FOR EACH BEAM, FIRST LINE IS MASS I, SECOND LINE IS MASS J

  I   J   M   N      FX           FY           FZ           MX           MY           MZ

  1   2   0   0  -3.2126D+03   0.0         -7.8046D+02   0.0         -9.0350D+04   0.0
                  3.2126D+03   0.0          7.8044D+02   0.0          7.3484D+03   0.0

  2   3   0   0  -1.2434D+04   0.0          2.5904D+04   0.0          2.7072D+04   0.0
                  1.2424D+04   0.0         -2.5909D+04   0.0          3.9937D+06   0.0

  3   4   0   0  -3.6942D+04   0.0         -4.7074D+03   0.0         -4.3550D+06   0.0
                  3.6945D+04   0.0          4.6809D+03   0.0          3.5045D+06   0.0

  4   5   0   0  -4.9317D+04   0.0         -5.7191D+04   0.0         -3.8168D+06   0.0
                  4.9300D+04   0.0          5.7206D+04   0.0         -7.9078D+06   0.0

  5   6   0   0   1.6362D+05   0.0          1.8610D+05   0.0          6.1010D+07   0.0
                 -1.6251D+05   0.0         -1.8707D+05   0.0         -3.6874D+07   0.0

  6   7   0   0   1.3294D+05   0.0          1.6081D+05   0.0          3.8531D+07   0.0
                 -1.3264D+05   0.0         -1.6106D+05   0.0         -2.5059D+07   0.0

  7   8   0   0   1.2470D+05   0.0          1.2375D+05   0.0          2.5199D+07   0.0
                 -1.2441D+05   0.0         -1.2404D+05   0.0         -7.5170D+06   0.0

  8   9   0   0   1.1585D+05   0.0          5.9675D+04   0.0          5.6138D+06   0.0
                 -1.1580D+05   0.0         -5.9769D+04   0.0         -1.0533D+05   0.0

  9  10   0   0   2.0904D+04   0.0          1.7141D+04   0.0         -1.1504D+05   0.0
                 -2.0910D+04   0.0         -1.7134D+04   0.0          2.8314D+06   0.0
```

Figure 2-23. KRASH85 Time History Output (Sheet 4 of 10)

```
                 3.03863D+03    0.0           1.48077D+02    0.0           -2.38105D+00    0.0
                 3.03969D+03    0.0           1.24360D+02    0.0           -2.38105D+00    0.0
                -2.18525D+03    0.0          -9.44612D+03    0.0           -3.95044D+01    0.0
                -6.42838D+00    0.0          -5.72139D+00   -1.10172D+01    0.0           -6.89078D+00

MASS   20        6.99457D+02    0.0          -1.64051D+02    0.0            1.82746D-02    0.0
                 3.13462D+03    0.0           2.48923D+02    0.0            7.00759D-02    0.0
                 3.12955D+03    0.0           3.06162D+02    0.0            7.00759D-02    0.0
                -2.31844D+02    0.0           2.42072D+02    0.0           -5.21307D+00    0.0
                -5.45051D-01    0.0           5.89776D-02   -4.19059D-01    0.0            1.54281D-01

MASS   21        6.99436D+02    0.0          -1.63954D+02    0.0            2.01807D-02    0.0
                 3.13504D+03    0.0           2.51219D+02    0.0            7.59870D-02    0.0
                 3.12933D+03    0.0           3.14431D+02    0.0            7.59870D-02    0.0
                -1.91988D+02    0.0           9.88229D+01    0.0           -4.23776D+00    0.0
                -4.35479D-01    0.0          -3.60014D-01   -3.30037D-01    0.0           -2.72745D-01


NO MASS IMPULSE DATA REQUESTED

BEAM FORCES

STRAIN FORCES

  I   J   M   N      FX           FY            FZ           MX            MYI          MYJ           MZI           MZJ
  1   2   0   0   3.2204D+03   0.0          -8.0977D+02   0.0          -9.4847D+04   1.3053D+04   0.0           0.0
  2   3   0   0   1.4479D+04   0.0           2.6521D+04   0.0          -2.9057D+04   3.9602D+06   0.0           0.0
  3   4   0   0   3.7752D+04   0.0          -5.4781D+03   0.0          -4.2844D+06   3.4080D+06   0.0           0.0
  4   5   0   0   4.8613D+04   0.0          -5.7623D+04   0.0          -3.7026D+06  -7.8272D+06   0.0           0.0
  5   6   0   0  -1.7876D+05   0.0           1.7065D+05   0.0           6.0795D+07  -3.6789D+07   0.0           0.0
  6   7   0   0  -1.2388D+05   0.0           1.6789D+05   0.0           3.8496D+07  -2.5045D+07   0.0           0.0
  7   8   0   0  -1.3734D+05   0.0           1.0991D+05   0.0           2.5150D+07  -7.4656D+06   0.0           0.0
  8   9   0   0  -1.2596D+05   0.0           3.3555D+04   0.0           5.5220D+06  -3.1985D+04   0.0           0.0
  9  10   0   0  -2.4314D+04   0.0           1.2374D+04   0.0          -1.8668D+05   2.8385D+06   0.0           0.0
  5  11   0   1  -5.0823D+04  -1.0766D+05  -1.7100D+05   3.0071D+07  -1.0523D+07  -1.1320D+07   2.1650D+07  -7.0973D+06
 11  12   1   0   9.0812D+03  -6.0953D+03   3.0186D+04  -3.0715D+06   5.0595D+06   1.6807D+05   3.4409D+06  -2.3657D+06
 12  13   0   0  -4.5120D+03  -1.4623D+04   1.7306D+03  -1.5069D+06  -1.1718D+06   1.4900D+04   2.8232D+06  -1.3321D+05
 13  14   0   0   2.3996D+03  -2.4318D+04  -1.1922D+04  -1.0093D+06  -1.7605D+04  -4.4925D+05   3.1702D+05   4.1981D+06
 14  15   0   1   5.9501D+04   4.2940D+04   1.5548D+03   2.6171D+05   5.1821D+05  -2.2547D+05  -4.5155D+06  -3.5691D+06
 12  16   1   1   3.7515D+03  -5.4960D+02  -8.1484D+03   5.0611D+04  -9.9520D+05   3.7504D+05   1.3341D+04   2.0486D+04
 14  17   1   1   1.1199D+04   8.3250D+02   5.1068D+03  -2.0717D+04   2.4664D+05   1.4199D+05  -6.8622D+04   5.8728D+03
 11  18   2   0  -1.9229D+04   2.0351D+03  -5.4773D+04  -2.2337D+03  -5.3310D+06   5.7595D+05  -2.0194D+05   1.4920D+04
 11  18   3   0  -2.9907D+01   2.0351D+03  -5.4773D+04  -2.2337D+03  -5.3310D+06   5.7595D+05  -2.0194D+05   1.4920D+04
  2  19   1   0  -3.5208D+03   0.0          -9.6641D+03   0.0          -7.2640D+05   1.2916D+05   0.0           0.0
  6  12   0   0   1.7741D+04   5.6656D+03  -5.3383D+03   1.2634D+06  -1.5613D+06   0.0          -1.6571D+06   0.0
  9  14   0   0   9.3714D+04   0.0          -4.1581D+03   7.0787D+05  -1.8226D+06  -9.3357D+05   0.0           0.0
 12   0   0   0  -3.4298D+04   0.0           0.0          0.0          -4.7960D+05   4.7960D+05   5.0704D+05  -5.0704D+05
  2  20   0   0  -7.7092D+02   0.0           9.0175D+01   0.0           9.8263D+02   8.1450D+02   0.0           0.0
  2  21   0   0  -1.1271D+03   0.0           8.4213D+01   0.0           8.1578D+02   8.5485D+02   0.0           0.0
 15  16   0   0   0.0          0.0           0.0          0.0           0.0          0.0           0.0           0.0
 15  16   2   2   0.0          0.0           0.0          0.0           0.0          0.0           0.0           0.0
 15   0   0   0   0.0          0.0           0.0          0.0          -2.8606D+05   2.8606D+05   5.0542D+05  -5.0542D+05
 15   0   2   0  -7.4156D+04   0.0           0.0          0.0          -2.8606D+05   2.8606D+05   5.0542D+05  -5.0542D+05

TOTAL FORCES (STRAIN+DAMPING)

  I   J   M   N      FX           FY            FZ           MX            MYI          MYJ           MZI           MZJ
  1   2   0   0   3.2023D+03   0.0          -8.2173D+02   0.0          -9.0350D+04   7.3484D+03   0.0           0.0
  2   3   0   0   1.4023D+04   0.0           2.5080D+04   0.0           2.7072D+04   3.9937D+06   0.0           0.0
```

Figure 2-23. KRASH85 Time History Output (Sheet 5 of 10)

```
  5  11   0   1  -1.0991D+05  -7.9151D+03  -1.7925D+05   2.1963D+07  -2.6509D+07  -1.8147D+07
                   1.1345D+05   9.1582D+03   1.7697D+05  -5.4247D+05   2.8656D+07   4.7894D+06

 11  12   1   0  -1.0846D+04  -7.2746D+03   2.9891D+04  -3.1465D+06   4.5160D+06  -3.4309D+06
                   1.1041D+04   7.2995D+03  -2.9814D+04  -1.5609D+06  -2.8357D+06   2.1251D+06

 12  13   0   0  -1.0411D+04   1.1198D+04   2.2769D+03   1.8929D+06   1.0193D+06  -2.6723D+06
                   1.0416D+04  -1.1219D+04  -2.1463D+03  -2.0613D+06  -6.3144D+05  -5.0270D+03

 13  14   0   0  -2.0702D+04   1.3132D+04  -1.1534D+04   2.0292D+06  -6.6071D+04  -2.2642D+05
                   2.0605D+04  -1.3072D+04   1.1774D+04   7.2448D+04  -6.5108D+05  -4.2694D+06

 14  15   0   1   3.7826D+03  -7.3206D+04  -3.9466D+03  -7.8554D+05  -2.8357D+05   4.4812D+06
                  -3.7376D+03   7.3176D+04   4.5021D+03   6.0526D+05  -2.8216D+04   9.8394D+05

 12  16   1   1   4.0504D+03  -3.1135D+02  -7.1571D+03   4.1307D+05   1.2946D+06   1.8661D+05
                  -4.3214D+03  -5.1596D+01   7.0035D+03  -5.3018D+04  -1.8392D+05  -4.3435D+04

 14  17   1   1   1.1542D+04   7.9513D+02   5.5375D+03   1.3849D+05  -2.7183D+05  -2.5773D+05
                  -1.1370D+04   3.6939D+02  -5.9239D+03   1.7141D+03   1.1959D+05   1.1744D+04

 11  18   2   0  -4.8129D+04  -1.6132D+03  -2.4754D+05   3.4899D+06  -2.6918D+07  -5.0397D+05
                   5.7370D+04   1.9422D+03   2.4557D+05  -1.4902D+04   5.7359D+05   2.3482D+03

 11  18   3   0  -5.4282D+04  -1.8154D+03  -1.3882D+03   2.1811D+05  -5.8758D+06  -5.6847D+05
                   5.4295D+04   1.8228D+03  -6.4904D+02  -1.4902D+04   5.7359D+05   2.3482D+03

  2  19   1   0  -9.2882D+03   0.0         -3.7061D+04   0.0         -6.2824D+05   0.0
                   1.0312D+04   0.0          3.6789D+04   0.0          1.3176D+05   0.0

  6  12   0   0   1.2151D+04  -1.4974D+04  -4.8560D+03   1.9138D+06  -6.1939D+05   1.7182D+06
                  -1.2046D+04   1.5015D+04   4.9907D+03  -4.8797D+05   1.2296D+06  -3.0638D+04

  9  14   0   0   4.5076D+04  -8.3152D+04  -3.1947D+03   1.9062D+06   2.1798D+05   3.0019D+04
                  -4.4676D+04   8.3409D+04   1.7933D+03   5.0708D+05   1.0839D+06  -2.9935D+04

 12   0   0   0  -2.2266D+01  -3.3976D+04   2.2143D+02  -3.5194D+05  -2.5788D+03  -4.3107D+05
                                   THERE IS NO MASS AT J END OF THIS BEAM

  2  20   0   0   5.2522D+02   0.0          9.4172D+02   0.0         -5.3233D+03   0.0
                  -5.2678D+02   0.0         -9.4086D+02   0.0         -5.2131D+03   0.0

  2  21   0   0   0.0          0.0          0.0          0.0          0.0          0.0
                  -4.1530D+02   0.0         -1.3598D+03   0.0         -4.2378D+03   0.0

 15  16   0   0   0.0          0.0          0.0          0.0          0.0          0.0
                   0.0          0.0          0.0          0.0          0.0          0.0

 15  16   2   2   0.0          0.0          0.0          0.0          0.0          0.0
                   0.0          0.0          0.0          0.0          0.0          0.0

 15   0   0   0   0.0          0.0          0.0         -2.9991D+05  -7.3245D+03  -4.9326D+05
                                   THERE IS NO MASS AT J END OF THIS BEAM

 15   0   2   0  -3.4672D+02  -7.4144D+04   1.3118D+03  -2.9991D+05  -7.3245D+03  -4.9326D+05
                                   THERE IS NO MASS AT J END OF THIS BEAM


BEAM RELATIVE DEFLECTIONS AND ROTATIONS AND BEAM EULER ANGLES (INCHES AND DEGREES)
```

Figure 2-23. KRASH85 Time History Output (Sheet 6 of 10)

```
    BEAM              DEFLECTION (J-I)                              ROTATIONS (J-I)                      ROTATIONS (J+I)        V EULER ANGLES
                                                                                                                           B
  I   J  M  N       X           Y            Z          PHI          THETA        PSI          THETA         PSI         M THETA    PSI
  1   2  0  0  1.0165D-03  0.0          -5.5701D-04  0.0           5.0359D-04  0.0          -2.8429D-01  0.0          0  -1.9  180.0
  2   3  0  0  6.4476D-03  0.0          -2.2363D-02  0.0           2.3795D-02  0.0          -2.5999D-01  0.0          0  -4.7  180.0
  3   4  0  0  1.6781D-02  0.0          -5.9455D-02  0.0           4.1006D-02  0.0          -1.9519D-01  0.0          0  -2.1  180.0
  4   5  0  0  1.6486D-02  0.0           2.0709D-03  0.0          -1.7385D-02  0.0          -1.7157D-01  0.0          0  -2.7  180.0
  5   6  0  0 -4.2575D-02  0.0           4.4932D-01  0.0          -3.3865D-01  0.0          -5.2761D-01  0.0          0   3.7  180.0
  6   7  0  0 -1.7412D-02  0.0           8.0283D-02  0.0          -1.0724D-01  0.0          -9.7350D-01  0.0          0  -4.7  180.0
  7   8  0  0 -4.6039D-02  0.0           2.1871D-01  0.0          -1.3188D-01  0.0          -1.2126D+00  0.0          0   4.5  180.0
  8   9  0  0 -5.5706D-02  0.0           8.8372D-02  0.0          -4.6500D-02  0.0          -1.3910D+00  0.0          0  10.6  180.0
  9  10  0  0 -2.0843D-02  0.0          -2.7262D-02  0.0           2.0637D-02  0.0          -1.4169D+00  0.0          0   9.7  180.0
  5  11  0  1 -1.2023D-02 -1.2215D-01 -1.6645D-01  1.2066D+00 -1.8286D-02 -9.4856D-02  5.0365D-02 -7.6441D-02 0  -5.8  -68.7
 11  12  1  0  2.4887D-03 -4.5406D-02  4.3635D-01 -3.0851D-01 -2.1292D-01 -2.8345D-02  1.4841D+00  1.9016D-01 0   5.8 -117.1
 12  13  0  0 -1.4742D-03 -5.6197D-02 -4.5999D-01 -4.1797D-01  2.9845D-01 -2.6862D-02  1.6095D+00  1.2497D-01 0   5.5 -119.9
 13  14  0  0  1.0928D-03  9.6950D-02 -8.7936D-01 -5.8765D-01  3.4814D-01  9.7928D-02  2.2490D+00  1.6861D-01 0   8.0 -123.9
 14  15  0  1  5.6013D-02  4.0334D-01  6.2125D-01  2.7516D-01 -3.3426D-01  6.3806D-02  2.2846D+00  3.8560D-01 0   6.0 -122.9
 12  16  1  1  3.3985D-03  1.6671D-03 -2.9704D-01  2.4985D-01  3.8862D-01  3.1455D-02 -9.4644D-01  9.8983D-02 0   0.6    0.0
 14  17  1  1  1.0145D-02  1.3100D-01  4.4110D-02 -1.0227D-01 -2.9677D-02  1.5342D-01 -3.9651D-01  5.8823D-01 0   0.8    0.3
 11  18  2  0 -7.4061D+00  7.5502D-02 -2.1725D+00 -6.9119D-03  2.1480D+00  7.5196D-02  4.2266D+00  9.1959D-01 1   1.5 -179.5
 11  18  3  0 -7.4061D+00  7.5502D-02 -2.1725D+00 -6.9119D-03  2.1480D+00  7.5196D-02  4.2266D+00  9.1959D-01 1   1.5 -179.5
  2  19  1  0 -1.2587D+00  0.0         -1.0678D+00  0.0           1.5865D+00  0.0          1.3027D+00  0.0          1  -0.1  180.0
  6  12  0  0  1.2749D-02  2.2501D-01 -2.2261D+00  1.1607D+00 -5.8914D-02  9.9165D-03  2.6086D-01  2.7488D-02 0  -0.9  -68.3
  9  14  0  0  1.5262D-01  1.5855D+00 -9.9282D+00  1.4739D+00  8.4410D-01  2.2855D-01  1.5286D+00  2.3372D-01 0   0.3  -61.6
 12   0  0  0 -4.5802D-02 -3.5662D-01 -3.5418D+00  0.0           7.4676D-01 -7.5189D-02  0.0          0.0          0   0.0   90.0
  2  20  0  0 -7.5377D-02  0.0           7.5738D-02  0.0          -9.4619D-02  0.0          1.8917D-01  0.0          1   0.9    0.0
  2  21  0  0 -1.7220D-01  0.0           5.3248D-02  0.0           1.4585D-02  0.0          2.9837D-01  0.0          1   1.0    0.0
 15  16  0  0  7.4813D-02 -7.9765D-01  1.8515D+00 -3.2985D-01  2.5063D-01 -1.3958D-01 -1.5407D+00  2.0390D-01 0  -9.2   46.8
 15  16  2  2  7.4813D-02 -7.9765D-01  1.8515D+00 -3.2985D-01  2.5063D-01 -1.3958D-01 -1.5407D+00  2.0390D-01 0  -9.2   46.8
 15   0  0  0 -8.4888D-01 -6.9222D+00 -2.6120D+01  0.0           2.0219D+00 -5.3585D-01  0.0          0.0          0   0.0   90.0
 15   0  2  0 -8.4888D-01 -6.9222D+00 -2.6120D+01  0.0           2.0219D+00 -5.3585D-01  0.0          0.0          0   0.0   90.0
```

```
EXTERNAL SPRINGS
                                                        GROUND CONTACT POINT LOADS                GROUND CONTACT POINT LOADS
                                                          IN GROUND OR SLOPE AXES                      IN MASS AXES
                                           SPRING
MASS SPRING  SPRING          GROUND      COMPRESSION  X(+ AFT OR    Y(+ LEFT) Z(+ UP OR NOR-      X            Y             Z
  I  K  M  COMPRESSION     DEFLECTION       LOAD      DOWN SLOPE)             MAL TO SLOPE)  (+ FORWARD)   (+ RIGHT)     (+ DOWN)

  1  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  2  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  3  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  4  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  5  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  6  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  7  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  8  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
  9  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 10  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 11  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 12  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 13  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 14  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 15  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 16  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 17  3  0  0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0            0.0
 18  3  0  4.82097D+00    0.0            1.70589D+05    5.11364D+04    3.16689D+02    1.70458D+05   -5.76055D+04   -1.77376D+03   -1.68373D+05
 19  3  0  4.32507D+00    0.0            3.84812D+04    1.15440D+04    0.0            3.84800D+04   -1.18439D+04    0.0           -3.83888D+04
```

Figure 2-23. KRASH85 Time History Output (Sheet 7 of 10)

```
DRI RESULTS: MASS NO. AND DRI VALUE

 MASS         DRI
  21       1.12790D+00

VEHICLE C.G. TRANSLATIONAL VELOCITIES, GROUND AXES, BASED ON SYSTEM LINEAR MOMENTUM

            XDOT          YDOT           ZDOT
           (+FWD)       (+RIGHT)        (+DOWN)
        3.12984D+03    0.0            2.67220D+02
```

Figure 2-23. KRASH85 Time History Output (Sheet 8 of 10)

```
                        ***** ENERGY DISTRIBUTION *****
                 TOTAL SYSTEM ENERGY = KE + PE - EW + SE + DE + CE + FE
                        TOTAL SYSTEM ENERGY       2.43033D+09

                           ENERGY DISTRIBUTION RELATED TO MASS ELEMENTS
 MASS       MASS         KINETIC ENERGY(KE)       POTENTIAL ENERGY(PE)          EXTERNAL WORK(EW)
  NO      DEVIATION      ENERGY      PERCENT       ENERGY      PERCENT          WORK        PERCENT

   1      0.001197     2.01999D+07    0.847      2.33695D+05    1.009       -1.43960D+03     0.060
   2      0.001206     1.15564D+08    4.845      1.30646D+06    5.640       -9.69047D+03     0.402
   3      0.001039     1.95593D+08    8.200      2.00614D+06    8.661       -2.98910D+04     1.241
   4      0.000793     1.67417D+08    7.019      1.63967D+06    7.079       -7.78678D+04     3.233
   5      0.000535     2.78154D+08   11.662      2.51555D+06   10.860       -1.34441D+05     5.581
   6      0.000738     1.01032D+08    4.236      9.85451D+05    4.254       -3.61257D+04     1.500
   7      0.000840     1.17589D+08    4.930      1.08578D+06    4.688       -4.37605D+04     1.817
   8      0.001039     1.27135D+08    5.330      1.30005D+06    5.613       -1.61515D+04     0.671
   9      0.001200     7.27958D+07    3.052      9.17635D+05    3.962       -1.00612D+04     0.418
  10      0.001943     7.85898D+07    3.295      1.21610D+06    5.250        4.25240D+05   -17.683
  11      0.000318     2.47000D+08   10.356      2.02718D+06    8.752       -4.65260D+05    19.315
  12      0.000793     2.57721D+08   10.805      2.42265D+06   10.459       -8.22884D+05    34.161
  13      0.001572     1.35438D+08    5.678      1.46015D+06    6.304       -5.83790D+05    24.235
  14      0.001383     9.60843D+07    4.028      1.23164D+06    5.317       -4.49380D+05    18.655
  15      0.001539     3.92313D+07    1.645      5.48422D+05    2.368       -1.33778D+05     5.554
  16      0.000323     1.38690D+08    5.815      9.13234D+05    3.943       -1.07013D+04     0.444
  17      0.001363     1.32486D+08    5.554      1.12961D+06    4.877       -8.86676D+03     0.368
  18      0.167463     4.88138D+07    2.047      5.69590D+04    0.246        0.0             0.0
  19      0.092812     2.85414D+06    0.120      2.88565D+03    0.012        0.0             0.0
  20      0.000312     1.28081D+07    0.537      1.64051D+05    0.708        0.0             0.0
  21      0.0          0.0            0.0        0.0            0.0          0.0             0.0

ENERGY TOTALS          2.38520D+09               2.31633D+07                 -2.40088D+06
PERCENT OF SYSTEM TOTAL  98.143                    0.953                       -0.099


                           ENERGY DISTRIBUTION RELATED TO BEAM ELEMENTS
         BEAM      MASS        NODE        STRAIN ENERGY(SE)          DAMPING ENERGY(DE)
          NO      I    J      M    N       ENERGY       PERCENT        ENERGY       PERCENT

          1       1    2      0    0     1.98264D+00     0.000      2.42797D-01     0.000
          2       2    3      0    0     5.98510D+02     0.036      3.32429D+01     0.001
          3       3    4      0    0     1.70941D+03     0.101      8.88479D+01     0.004
          4       4    5      D    0     1.53717D+03     0.091      8.17181D+01     0.004
          5       5    6      0    0     1.51016D+05     8.965      6.40275D+02     0.028
          6       6    7      0    0     3.12806D+04     1.857      8.48154D+01     0.004
          7       7    8      0    0     2.37984D+04     1.413      1.92747D+02     0.008
          8       8    9      0    0     5.01829D+03     0.298      1.20528D+02     0.005
          9       9   10      0    0     6.02662D+02     0.036      6.03631D+01     0.003
         10       5   11      0    1     6.92846D+05    41.131      1.58712D+04     0.697
         11      11   12      1    0     3.07812D+04     1.827      5.24385D+03     0.230
         12      12   13      0    0     1.89155D+04     1.123      1.88312D+03     0.083
         13      13   14      0    0     2.29376D+04     1.362      7.44173D+02     0.033
         14      14   15      0    1     2.02181D+04     1.200      5.15348D+01     0.002
         15      12   16      1    1     5.23997D+03     0.311      7.74293D+02     0.034
         16      14   17      1    1     4.28300D+02     0.025      6.71230D+01     0.003
         17      11   18      2    0     3.46923D+05    20.595      2.22694D+06    97.742
         18      11   18      3    0     1.80908D+05    10.740     -4.09922D+03    -0.180
         19       2   19      1    0     1.12497D+04     0.668      2.74358D+04     1.204
```

Figure 2-23. KRASH85 Time History Output (Sheet 9 of 10)

```
BEAM      MASS        NODE         STRAIN ENERGY(SE)         DAMPING ENERGY(DE)
 NO      I    J       M   N        ENERGY      PERCENT        ENERGY      PERCENT

 20       6   12      0   0      3.89876D+04     2.314       9.52826D+02     0.042
 21       9   14      0   0      6.00473D+04     3.565       1.77836D+02     0.008
 22      12    0      0   0      4.24978D+03     0.252       9.78256D+02     0.043
 23       2   20      0   0      3.18213D+01     0.002       2.24945D+01     0.001
 24       2   21      0   0      0.0             0.0         0.0             0.0
 25      15   16      0   0      0.0             0.0         0.0             0.0
 26      15   16      2   2      0.0             0.0         0.0             0.0
 27      15    0      0   0      7.41096D+03     0.440       1.85711D+01     0.001
 28      15    0      2   0      2.77628D+04     1.648       1.85711D+01     0.001

ENERGY TOTALS                    1.68450D+06                 2.27838D+06
PERCENT OF SYSTEM TOTAL              0.069                       0.094

                 ENERGY DISTRIBUTION RELATED TO SPRING ELEMENTS
 SPRING   DIRECTION   NODE       CRUSHING ENERGY(CE)        FRICTION ENERGY(FE)
   NO                              ENERGY      PERCENT        ENERGY      PERCENT

    1         3         0       0.0             0.0        0.0             0.0
    2         3         0       0.0             0.0        0.0             0.0
    3         3         0       0.0             0.0        0.0             0.0
    4         3         0       0.0             0.0        0.0             0.0
    5         3         0       0.0             0.0        0.0             0.0
    6         3         0       0.0             0.0        0.0             0.0
    7         3         0       0.0             0.0        0.0             0.0
    8         3         0       0.0             0.0        0.0             0.0
    9         3         0       0.0             0.0        0.0             0.0
   10         3         0       0.0             0.0        0.0             0.0
   11         3         0       0.0             0.0        0.0             0.0
   12         3         0       0.0             0.0        0.0             0.0
   13         3         0       0.0             0.0        0.0             0.0
   14         3         0       0.0             0.0        0.0             0.0
   15         3         0       0.0             0.0        0.0             0.0
   16         3         0       0.0             0.0        0.0             0.0
   17         3         0       0.0             0.0        0.0             0.0
   18         3         0       8.32018D+05    91.063      1.42468D+07    97.035
   19         3         0       8.16539D+04     8.937      4.35351D+05     2.965

 ENERGY TOTALS                  9.13672D+05                1.46822D+07
 PERCENT OF SYSTEM TOTAL            0.038                      0.604
```

Figure 2-23. KRASH85 Time History Output (Sheet 10 of 10)

velocity of mass I, using the same sign convention as for the Euler angles. PDOT, QDOT and RDOT are the body axes components of the angular accelerations of mass I. None of these orientation quantities is output for the node points, since these are the same as for the mass to which a given node point is attached.

XIMPULSE, YIMPULSE, ZIMPULSE are the accumulated area under the filtered acceleration response curve (G-SEC). Normally the user should plot these data to evaluate its meaning.

2.3.3.2.2 Internal Beam Data

The STRAIN FORCES and TOTAL FORCES (STRAIN + DAMPING) are both output in the same format. FX, FY and FZ are the forces in beam axes acting upon the beam at the j end of the beam. Equal and opposite forces act upon the beam at the i end. MX is the torsion acting at the j end; again an equal and opposite torsion acts at the i end. MYI and MYJ are the bending moments at each end of the beam, acting about the beam y axis. MZI and MZJ are the moments acting about the beam z axis. In general, the moments acting at the i and j ends of the beam are not equal. The i and j ends of the beam are at masses i and j, unless the beam connects to a node point. In this case the i end of the beam is actually located at node point I, M, and the j end at node point J, N. M or N equal to zero means there is no node point; direct mass connection is used. The sign convention for these loads is shown in figure 2-18.

The total beam forces can also be output in a format which shows, for each beam, the loads acting at the I and J masses. This output is titled COMPONENTS OF TOTAL BEAM FORCES ACTING ON MASSES I AND J. For each beam the first line of output shows the forces on mass I, the second line shows mass J. These loads are positive forward, right and down, in mass axes, with moments using right-hand-rule about those axes. The loads are those acting on the masses, not the loads acting on the beams.

The beam X, Y and Z deflection data are presented in relative form, i.e., the values represent deflections at the j end minus those at the i end. The beam rotation data are given in both (J-I) and (J+I) terms. This is done because the strain forces are calculated using both sum and difference terms.

Note that these angles are all in degrees, rather than radians. If the actual rotations at the j and i beam ends are desired, they can be calculated from the output data as

$$\text{THETA(J)} = \frac{\text{THETA(J+I)} + \text{THETA(J-I)}}{2}$$

$$\text{THETA(I)} = \frac{\text{THETA(J+I)} - \text{THETA(J-I)}}{2}$$

Similar equations apply to PSI.

The beam lateral deflections Y and Z which are printed out are not simply the (J-I) values. The θ and ψ rotations of mass I cause Z and Y deflections at end J, which in themselves cause no beam loads. These deflection components are removed from the output deflections. The output deflections are the following

$$Y_{\text{output}} = (Yj - Yi) - \ell \ \psi i$$

$$Z_{\text{output}} = (Zj - Zi) + \ell \ \theta i$$

The Euler angles defining the current orientation of the beam axes are also output in degrees. The column of integers titled VBM define which beams, if any, are treated as vertical beams. For vertical beams, VBM=1; for normal beams, VBM=0. For normal beams, the following procedure is used to determine the current beam axes orientation.

- o Start with the ground fixed axis system, with X positive forward, Y positive right and Z positive downward.
- o Rotate PSI degrees about the Z axis, using right-hand-rule for positive rotations.
- o Rotate THETA degrees about the new rotated Y axis, using right-hand-rule for positive rotations.

For vertical beams (VBM=1), the same procedure is used, but the initial orientation of the X, Y, Z axis is different. In this case, the initial orientation is X positive up, Y positive right and Z positive forward.

For either axis orientation system, there is actually a final rotation of PHI about the X axis. PHI is not shown primarily due to output format line width limitations. However, PHI is normally rather small and will not affect the user's interpretation of the orientation of the beam axes.

2.3.3.2.3 External Spring Data

For each external spring, the spring compression in inches and compression load in pounds is output. These are along the spring axis, which is oriented parallel to one of the mass axes. The ground deflection is also shown; this deflection will be zero if the ground flexibility is input as zero. The ground contact point loads are given in two coordinate systems, ground axes and mass axes. If the spring in question is on a slope, then slope axes are used instead of ground axes. The output titles for these quantities are self-explanatory.

2.3.3.2.4 DRI and c.g. Velocity Data

For each beam element which has been defined as a Dynamic Response Index (DRI) type element, the J mass and DRI number are shown. Volume I, Section 1.3.12 explains the theory and usage of DRI elements.

The overall vehicle c.g. velocities, in ground axes, are always output. These velocities are calculated such that the total vehicle weight, with these velocity components, would yield the same linear momentum as that existing in the total system of NM masses. Section 1.3.9 of Volume I explains how these values are derived. This output, particularly the time-history plot of same, is a very useful indicator of the overall vertical motion of the system. Since the system kinetic energy is a scalar quantity, there is no way to separate the kinetic energy due to horizontal motion from that due to vertical motion. Therefore, for analyses in which the horizontal velocity is much larger than the vertical, system kinetic energy is not very useful in determining when the vertical impact velocity has been absorbed.

The vertical component of the overall c.g. velocity can be used for this purpose.

2.3.3.2.5 Energy Distribution Data

The total system energy is computed for each print time increment by summing the energy components as following:

$$TSE = \Sigma\, KE + \Sigma\, PE + \Sigma\, SE + \Sigma\, DE + \Sigma\, CE + \Sigma\, FE - \Sigma\, EW$$

where

TSE = Total System Energy
KE = Kinetic Energy
PE = Potential Energy
SE = Strain Energy
DE = Damping Energy
CE = Crushing Energy
FE = Friction Energy
EW = External Work

In the above, the kinetic energy, the potential energy and the external work are summed over the number of masses; the strain energy and damping energy are summed over the number of beams; and the crushing energy and friction energy are summed over the number of crushing springs. The total system energy determined at time zero is used as a reference to evaluate the acceptability of the numerical integration process used in the analysis. As long as the total system energy remains within 0.5 percent of the reference value, the gross effects of the integration process are considered acceptable. Effects of the integration process on localized regions of the model still must be evaluated however, see mass energy deviation discussion below. For analysis cases which do not execute the KRASHIC option, the initial total system energy is simply the sum of the kinetic energy and the potential energy at time zero. For analyses which do execute the KRASHIC option or which use an initial condition data set previously generated in a KRASHIC run, the initial total system energy is the sum of the kinetic and potential energies at time zero and also the strain energy, the damping energy and the work associated with any externally applied forces produced while bringing the model into equilibrium at time zero. Note that the since the energy related to the externally applied forces (external work) represents energy which is added to the system, it must be subtracted from the other energy terms in the above energy equation in order to maintain the desired energy balance referenced to time zero.

A summary of the energy components related to mass elements (mass energy deviation, kinetic energy, potential energy and external work) are tabulated together. Likewise, energy components related to beam elements (strain energy and damping energy) and those related to crushing spring elements (crushing energy and friction energy) are also summarized together for easy reference.

Mass Element Energies

The mass deviation tabulated in this summary is defined as the variation in the total energy of each mass from its initial value at time zero, divided by the initial total energy of the system and expressed as a percentage. Ideally, the variations should all be zero. In actual practice, however, errors associated with the numerical integration process result in deviations from the ideal. The mass deviation values can be used for pinpointing areas of the model that may be causing numerical accuracy problems and alerting the program user to the possible need for a finer integration time step. If the largest mass deviation occurs in a region of the model that is not of great interest, the user can elect to accept the inaccuracy indicated by the deviation. On the other hand, if the deviation occurs in an area that is of vital interest, the user can use a smaller integration time interval to achieve the desired accuracy in that region of the model. In typical applications, a few individual mass energies may deviate 2 to 5 percent from the 100 percent ideal, while the total energy of the entire system remains within 0.5 percent or less. This accuracy is generally considered acceptable for the numerical integration process. However, the program user is free to adjust the integration time step to suit his or her own personal criterion for the accuracy of the individual mass integrations.

The system kinetic energy should reduce to zero at the conclusion of the analytical run. From a practical standpoint, however, one can expect individual elements to oscillate slightly after the vehicle comes to rest, leaving some residual kinetic energy in the system long after the responses of interest have occurred.

If the vehicle is impacting on a flat surface (no slope) and a substantial portion of the initial kinetic energy is due to forward velocity (parallel to the ground), then a much larger percentage of the initial kinetic energy may remain after the significant damage phase of the crash. The remaining energy is accounted for by the vehicle sliding along the ground with a substantial forward velocity. In this case, the vehicle c.g. translational velocities, printed earlier, provide a better indication of whether the major response phase has been adequately covered. In general, the ZDOT or vertical vehicle translational velocity should be reduced to zero, indicating that the vehicle has ceased its downward motion. This situation can also be seen when the system potential energy reaches a minimum.

The potential energies include only the height effect of the masses above the ground plane. Positive potential energy results when the mass element is above the ground plane while negative potential energy results when the mass element is below the ground plane. This representation is different than that included in earlier versions of KRASH. In the earlier versions, the potential energies include both the height effect and the work done by externally applied forces. In the present version of KRASH, the external work components have been separated from the potential energy component and are listed separately.

Included in the external work component is the work done by the following input external forces and accelerations:

- Applied force time histories defined by cards 3400 - 3500
- Applied acceleration time histories defined by cards 3400 - 3500
- Aerodynamic forces defined by card 3100

Positive external work results when the applied external force acts in the same direction as the net deflection increment of the mass element while negative external work results when the applied external force and net deflection increment act in opposite directions.

Beam Element Energies

The individual internal beam strain energies provide the user with valuable insight into the temporal and spatial flow of energy in the vehicle. Generally speaking, the strain energy concentrates initially near the point of impact, and as the strain energy grows it also becomes diffused throughout the vehicle. After the peak responses in the system occur, the overall system strain energy will decrease from its peak value as the internal beam elements unload.

Certain individual nonlinear beam elements may indicate negative strain energy. This circumstance may occur when large deflection loading and unloading occurs in the coupled bending degrees of freedom ($z-\theta$ or $y-\psi$), with nonlinear KR curves applied to these directions. This phenomenon is discussed in Section 1.3.16 of Volume I, and is due to the approximate nature of the nonlinear element analytical model. In practice, these negative strain energies are of such small magnitude relative to the overall system strain energy (usually less than 1 percent) that they do not invalidate the overall analysis. Furthermore, these negative energies tend to occur toward the end of the analysis, during the unloading phase, after the primary responses and damage of interest have been determined. The plastic hinge option should be used in lieu of KR tables in the coupled bending directions; negative strain energy will not occur with the plastic hinge option. It should also be noted that negative strain energy does not occur for linear beam elements, or for those that are nonlinear only in the uncoupled degrees of freedom (axial and torsion).

The damping energy of the internal beams is usually small in relation to the strain energy, typically being less than 20 percent of the strain energy, until late in the run when the strain energy has decreased substantially from its peak value. Note that damping energy always increases with time, since it is a dissipative energy that is not stored and released as with strain energy.

Crushing Spring Element Energies

Crushing and friction energies result from the deformation of the external springs and flexible ground for the former, and from sliding friction along the ground for the latter. The friction energy is also dissipative and hence monotonically increasing, whereas the crushing energy peaks and decreases similar to the strain energy. In general, a rather large percentage of the total system energy may be represented by the crushing energy. This situation is only natural since the external springs represent the structure in immediate contact with the ground that undergoes substantial deformation. In a typical vehicle crash analysis, the system crushing energy may be larger than the internal beam strain energy. However, they both represent actual airplane structure, the only distinction being location on the vehicle.

2.3.3.2.6 Internal Beam Stress Data

The stress data output are shown in figure 2-24, which is taken from the t = 0 output of the sample case. (Stress data output was not selected for the sample case, so none was output at t = 0.5 used for figure 2-23. At time zero, all output is printed regardless of what the user requests).

This output consists of ratios of current stress to failure level stress (corresponding to initial yielding), for four locations on each beam, using two failure theories. These theories are the maximum shear stress theory and the theory of constant energy of distortion. Section 1.3.17 of Volume I presents the method of calculating these ratios. Also shown in the output are the ratios of current compressive/tensile stress to the corresponding yield stress, and the ratio of current axial compressive load (when it is compressive) to the critical buckling load.

The stress data can be used as a guide for estimating the time at which the element begins to yield. When such a state is reached, a stiffness reduction factor (KR) may be developed for the affected member which then can be used to approximate the nonlinear response characteristics of that member. The user is cautioned to exercise extreme care in the interpretation of data presented in the summary since they do not include the effect of stress concentrations, geometric shape factors, and detail attachment practices at joints. In addition, limitations of the program require that gross regions of the vehicle structure be modeled using relatively simple number of structural elements. Thus, the more gross the structural region the less accurate the stress values. Also monitoring the response of a structural element which may exhibit a buckling mode of failure will require special consideration. In this case the critical buckling load becomes significant and a stiffness reduction factor should be developed which will approximate the buckling characteristics of the element.

Furthermore, the user should realize that once an element has yielded or buckled, the failure theories followed become invalid and, consequently, the most meaningful use of the stress data is to identify which element may fail and at what point in time such failures are apt to occur.

2.3.3.2.7 Initial Mass Acceleration Error Output

Figure 2-24 shows this output for the sample case. This information is only output at time zero, and has significance only if balanced initial conditions are used (KRASHIC and MSCTRAN are used to calculate balanced internal beam loads). For each mass in the system, the difference between the actual time zero acceleration calculated in KRASH85 and the theoretically correct value, based on airplane rigid body accelerations at time zero, is printed. A summary at the bottom shows the largest value and corresponding mass number for each of the six accelerations.

The reason that the time zero accelerations are not "exactly" equal to the theoretically correct values is because the accuracy of the KRASHIC/MSCTRAN iterations is limited by the number of significant figures used in the input and output data sets used with NASTRAN. The accuracy shown in figure 2-24 is representative of a typical large transport airplane model, using ten iterations of KRASHIC/NASTRAN. In general the results are quite good, with most translational accelerations accurate to within E-5 g's. Errors of this order should have no appreciable influence on the subsequent time history results, particularly for crash impacts which typically involve mass accelerations of

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ELEMENT STRESSES

                                              RATIO OF CURRENT STRESS / FAILURE STRESS                                   RATIO OF CURRENT
        BEAM                   MAXIMUM SHEAR STRESS THEORY              THEORY OF CONSTANT ENERGY OF DISTORTION       AXIAL/FAILURE       BUCK. /
 IJ    I   J  M  N     TOP       BOTTOM      LEFT       RIGHT          TOP       BOTTOM      LEFT       RIGHT        COMPR.    TENSILE    CR.BUCK.
                                                                                                                     STRESS    STRESS      LOAD

  1    1   2  0  0  6.636D-03 6.637D-D3 3.981D-03 3.981D-03   6.447D-03 6.637D-03 3.447D-03 3.447D-03   1.873D-07            2.847D-10
  2    2   3  0  0  7.081D-02 7.173D-02 2.653D-02 2.653D-02   6.878D-02 7.173D-02 2.298D-02 2.298D-02   4.625D-04            1.714D-06
  3    3   4  0  0  1.092D-01 1.095D-01 5.858D-02 5.858D-02   1.060D-01 1.095D-01 5.073D-02 5.073D-02   1.873D-04            6.916D-07
  4    4   5  0  0  1.462D-01 1.470D-01 4.779D-02 4.779D-02   1.420D-01 1.470D-01 4.139D-02 4.139D-02   3.898D-04            3.411D-06
  5    5   6  0  0  2.696D-01 3.181D-01 4.587D-02 4.587D-02   2.619D-01 3.181D-01 4.153D-02 4.153D-02   2.426D-02            1.047D-04
  6    6   7  0  0  2.432D-01 2.952D-01 6.616D-02 6.616D-02   2.362D-01 2.952D-01 5.875D-02 5.875D-02   2.600D-02            2.875D-05
  7    7   8  0  0  2.241D-01 2.921D-01 5.568D-02 5.568D-02   2.177D-01 2.921D-01 5.113D-02 5.113D-02   3.401D-02            1.174D-04
  8    8   9  0  0  1.466D-01 2.356D-01 4.960D-02 4.960D-02   1.424D-01 2.356D-01 4.839D-02 4.839D-02   4.454D-02            2.269D-04
  9    9  10  0  0  7.563D-02 8.609D-02 8.166D-02 8.166D-02   7.347D-02 8.609D-02 7.077D-02 7.077D-02   5.228D-03            5.442D-05
 10    5  11  0  1  1.052D-01 1.209D-01 9.239D-02 9.110D-02   8.979D-02 1.068D-01 8.145D-02 8.007D-02             4.754D-02
 11   11  12  1  0  5.357D-02 8.125D-02 6.156D-02 5.885D-02   4.802D-02 7.633D-02 5.797D-02 5.525D-02             5.056D-02
 12   12  13  0  0  1.700D-02 5.118D-02 4.083D-02 3.944D-02   1.528D-02 4.918D-02 3.594D-02 3.444D-02             1.981D-02
 13   13  14  0  0  2.526D-02 3.831D-02 3.459D-02 2.408D-02   2.343D-02 3.650D-02 3.330D-02 2.296D-02             2.700D-02
 14   14  15  0  1  2.141D-01 1.992D-01 1.106D-01 8.115D-02   1.881D-01 1.719D-01 1.073D-01 7.860D-02             9.236D-02
 15   12  16  1  1  1.446D-02 1.436D-02 4.276D-02 4.275D-02   1.353D-02 1.620D-02 3.468D-02 4.179D-02             4.490D-05
 16   14  17  1  1  1.360D-02 1.364D-02 4.083D-02 4.084D-02   1.274D-02 1.539D-02 3.312D-02 3.992D-02   1.876D-05            8.175D-07
 17   11  18  2  0  1.997D+00 1.997D+00 1.997D+00 1.997D+00   1.997D+00 1.997D+00 1.997D+00 1.997D+00             1.997D+00
 18   11  18  3  0  5.182D-01 5.182D-01 5.179D-01 5.180D-01   5.180D-01 5.181D-01 5.178D-01 5.179D-01             5.176D-01
 19    2  19  1  0  3.096D-01 3.094D-01 3.097D-01 3.097D-01   3.096D-01 3.094D-01 3.096D-01 3.096D-01             3.095D-01
 20    6  12  0  0  4.075D-02 1.370D-02 1.800D-02 2.139D-02   4.036D-02 1.213D-02 1.700D-02 2.055D-02   1.569D-02            4.704D-03
 21    9  14  0  0  1.183D-02 6.865D-02 4.133D-02 4.133D-02   1.150D-02 6.669D-02 3.989D-02 3.989D-02             3.909D-02
 22   12   0  0  0  5.892D-02 3.065D-02 4.580D-02 4.378D-02   5.892D-02 3.065D-02 4.580D-02 4.378D-02   4.479D-02            2.319D-02
 23    2  20  0  0  1.347D-01 1.462D-01 1.405D-01 1.405D-01   2.861D-01 3.106D-01 2.985D-01 2.985D-01   2.984D-01            9.754D-03
 24    2  21  0  0  4.179D-07 4.202D-07 4.191D-07 4.191D-07   8.881D-07 8.930D-07 8.906D-07 8.906D-07   8.906D-07            1.890D-08
 25   15  16  0  0  0.0       0.0       0.0       0.0         0.0       0.0       0.0       0.0         0.0                  0.0
 26   15  16  2  2  0.0       0.0       0.0       0.0         0.0       0.0       0.0       0.0         0.0                  0.0
 27   15   0  0  0  6.795D-03 6.795D-03 1.957D-03 1.957D-03   6.795D-03 6.601D-03 1.957D-03 1.901D-03   0.0                  0.0
 28   15   0  2  0  1.198D-01 1.062D-01 1.149D-01 1.110D-01   1.198D-01 1.062D-01 1.149D-01 1.110D-01   1.130D-01            3.553D-01
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DIFFERENCE BETWEEN ACCELERATIONS AT T=0 AND RIGID BODY ACCELERATIONS
FOR BALANCED INITIAL CONDITIONS (FROM SUBROUTINE NETFOR)
UNITS ARE G-S AND RAD/SEC-SQ
(LARGEST VALUES SHOWN AT BOTTOM EXCLUDE DRI MASSES)

  MASS        XACC             YACC             ZACC             PDOT             QDOT             RDOT

    1     -5.785218D-06    0.0              7.448886D-04    0.0              1.462068D-03    0.0
    2      2.857190D-06    0.0             -1.278784D-04    0.0              2.402460D-04    0.0
    3      7.800529D-07    0.0             -3.018795D-05    0.0             -1.598356D-04    0.0
    4     -2.165015D-06    0.0              4.048116D-05    0.0             -1.459396D-04    0.0
    5      7.112840D-06    0.0             -4.051466D-05    0.0             -4.572405D-04    0.0
    6     -6.137187D-05    0.0             -3.515869D-04    0.0             -1.527542D-03    0.0
    7      3.842915D-05    0.0              5.811271D-04    0.0              1.376480D-05    0.0
    8      2.224739D-04    0.0             -2.172363D-04    0.0              4.289834D-04    0.0
    9     -1.024338D-03    0.0              2.488137D-04    0.0              1.283577D-03    0.0
   10      9.193599D-05    0.0             -1.716671D-04    0.0              1.081596D-03    0.0
   11     -2.323922D-05    2.468612D-05    -4.752924D-05   -8.709168D-05    -3.234751D-04   -1.098419D-05
   12     -2.676107D-05   -1.611837D-04    -6.114438D-05    1.238406D-03    -6.726971D-05   -3.216417D-05
```

Figure 2-24. KRASH85 Internal Beam Stress Data and Initial Mass Acceleration Error Output (Sheet 1 of 2)

```
      13      2.113459D-04     5.876442D-04     1.845455D-04     8.414281D-04     9.167746D-05    -2.747495D-04
      14     -5.407140D-05    -1.834297D-03    -2.759907D-04    -4.265298D-03     8.362252D-04    -1.536517D-04
      15      6.585294D-04     1.423072D-03     2.543242D-04     1.548545D-02    -3.437049D-04    -2.504903D-03
      16      2.096302D-05    -1.260148D-06     8.367775D-06    -1.302555D-04    -7.231959D-05    -1.133793D-05
      17     -1.041489D-05    -3.236533D-06     3.208562D-05     1.983974D-05     4.273101D-04     4.047053D-05
      18     -1.257079D-06     9.430319D-06     2.926905D-04     1.650989D-03     3.646934D-05    -1.342542D-06
      19     -3.129507D-06     0.0              4.035505D-04     0.0              1.879055D-05     0.0
      20      1.212458D-06     0.0              3.028557D-07     0.0             -2.318446D-06     0.0
      21     -1.522101D-02     0.0              9.998823D-01     0.0             -3.875846D-08     0.0

LARGEST
  VALUE       1.024338D-03     1.834297D-03     7.443886D-04     1.548545D-02     1.527542D-03     2.504903D-03

MASS NO.           9               14                1               15                6               15
```

Figure 2-24. KRASH85 Internal Beam Stress Data and Initial Mass Acceleration Error Output (Sheet 2 of 2) five g's or more.

DRI masses are excluded from the largest value summary because the DRI beam elements always start with zero internal load and deflection in the axial direction. In subroutine NETFOR, where the theoretically exact initial accelerations are computed, it is assumed that the DRI mass is rigidly attached to the vehicle.

2.3.3.3 Summary Output

At the conclusion of the time history printout several summaries are presented, which include:

- Summary of internal beam yielding and rupture
- Summary of mass penetration into a control volume
- Summary of external spring loading and unloading
- Summary of plastic hinge moment formations
- Summary of energy distribution
- Time histories of interaction loads/summary of maximum load ratios
- Time histories of vehicle c.g. motions

The summaries are illustrated in figure 2-25.

Internal beam element yielding and rupture are summarized at the end of the run. For each occurrence of yielding or rupture, the time, beam identification and beam direction of yielding or rupture is output. Directions 1-6 correspond to beam axis directions x, y, z, Φ, θ and ψ, the latter three being rotations about the beam x, y and z axes. In addition the beam tension and compression rupture is noted. If a beam has a special KR curve that starts at a nonzero value, then this summary will indicate yielding at time zero. This output provides the user with a concise summary of the onset of beam nonlinearities and beam ruptures.

Also included in the internal beam yielding summary are occurrences of interaction loads exceeding the user defined load envelopes. In figure 2-25,

```
SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE
                    BEAM                   BEAM DIRECTION FOR  TENSION(+) OR
   TIME        IJ   I   J   M   N   YIELD       RUPTURE  COMPRESSION(-)

 0.030700      18  11  18   3   0     1            0            0
 0.071250      19   2  19   1   0     0            1           -1
 0.100000       9   9  10   0   0    15            0            3
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 1 of 11)

```
    SUMMARY OF EXTERNAL SPRING LOADING AND UNLOADING

        TYPES;1=INITIAL LOADING 2=MAX.LOADING 3=UNLOAD TO ZERO   FORCE 4=INITIATION OF RELOAD

        NOTE:SPRING RELOADS AT ZERO   FORCE(SEQ.1,2,3,4) OR AT FINITE FORCE VALUE(SEQ.1,2,4)

        NOTE:INITIAL DEFLECTION IS FIRST IMPACT IF NYPE=1,  OTHERWISE IT IS POINT AT WHICH RELOADING OCCUR FOR NTYPE=4

TIME(SEC)  MASS    NODE  DIRECTION  TYPE   INITIAL         MAXIMUM                 UNLOADED
            NO.     NO.   L=1,2,3    NO.  DEFLECTION   FORCE &/OR DEFLECT DEFLECT  & FORCE
 0.000850   18      0       3         1     0.0142    0.0          0.0      0.0       0.0
 0.027150   19      0       3         1     0.0093    0.0          0.0      0.0       0.0
 0.031250   18      0       3         2     0.0142    0.21D+06     5.9281   0.0       0.0
 0.031650   18      0       3         2     0.0142    0.21D+06     5.9295   0.0       0.0
 0.050700   18      0       3         4     4.8176    0.21D+06     5.9295   4.8176    0.17D+06
 0.071350   19      0       3         2     0.0093    0.14D+06     6.5908   0.0       0.0
 0.071450   19      0       3         2     0.0093    0.14D+06     6.5906   0.0       0.0
 0.075250   19      0       3         3     0.0093    0.14D+06     6.5906   5.2342    0.0
 0.080700   18      0       3         2     4.8176    0.33D+06     8.4122   4.8176    0.17D+06
 0.080850   18      0       3         2     4.8176    0.33D+06     8.4125   4.8176    0.17D+06
 0.097750   18      0       3         4     7.2872    0.33D+06     8.4125   7.2872    0.22D+06

SUMMARY OF PLASTIC HINGE FORMATIONS

                 BEAM           BEAM END
   TIME      IJ   I   J   M   N   MASS NO.     DIRECTION-NEWPIN
 0.061600     1   1   2   0   0      2              5        1
 0.064300     1   1   2   0   0      2              5        0
 0.068900     1   1   2   0   0      2             -5        1
 0.071600     1   1   2   0   0      2             -5        0
 0.072300     1   1   2   0   0      2              5        1
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 2 of 11)

```
                         ***** TEMPORAL ENERGY DISTRIBUTION SUMMARY *****
                       TOTAL SYSTEM ENERGY = KE + PE - EW + SE + DE + CE + FE

                       ********* PERCENT ENERGY DISTRIBUTION SUMMARY *********

   TIME        PERCENT       PERCENT                          PERCENT OF CURRENT TOTAL SYSTEM ENERGY
               MAXIMUM        TOTAL      - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
                MASS        . SYSTEM      KINETIC    POTENTIAL    EXTERNAL     STRAIN      DAMPING     CRUSHING    FRICTION
              DEVIATION       ENERGY       (KE)        (PE)       WORK(EW)      (SE)        (DE)         (CE)        (FE)

0.0            0.0           100.000      98.943      1.063        0.021       0.015       0.000       0.0         0.0
0.01000        0.012838      100.000      98.889      1.040       -0.004       0.015       0.000       0.012       0.040
0.02000        0.034519      100.001      98.750      1.018       -0.029       0.017       0.005       0.035       0.147
0.03000        0.081947      100.002      98.558      0.995       -0.053       0.029       0.017       0.051       0.296
0.04000        0.140086      100.004      98.351      0.974       -0.077       0.049       0.048       0.045       0.456
0.05000        0.167463      100.004      98.143      0.953       -0.099       0.069       0.094       0.038       0.604
0.06000        0.204250      100.004      97.930      0.933       -0.120       0.082       0.121       0.052       0.763
0.07000        0.569966      100.004      97.652      0.913       -0.139       0.080       0.140       0.090       0.985
0.08000        0.985395      100.005      97.352      0.895       -0.158       0.079       0.169       0.112       1.236
0.09000        0.985394      100.006      97.069      0.878       -0.176       0.096       0.213       0.096       1.472
0.10000        0.985394      100.005      96.835      0.861       -0.193       0.125       0.248       0.087       1.651

                          ********* ENERGY DISTRIBUTION SUMMARY *********

   TIME       TOTAL                                           ENERGY COMPONENT
              SYSTEM      - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - - -
              ENERGY        KINETIC      POTENTIAL     EXTERNAL       STRAIN        DAMPING       CRUSHING      FRICTION
                             (KE)          (PE)        WORK(EW)        (SE)          (DE)          (CE)          (FE)

0.0          2.43022D+09  2.40454E+09  2.58379E+07   5.16481E+05  3.56038E+05  1.25251E-10  0.0           0.0
0.01000      2.43023D+09  2.40324E+09  2.52795E+07  -9.05402E+04  3.58586E+05  5.54500E+03  2.88416E+05  9.69700E+05
0.02000      2.43024D+09  2.39985E+09  2.47285E+07  -6.95591E+05  4.22203E+05  1.14150E+05  8.53447E+05  3.57495E+06
0.03000    · 2.43027D+09  2.39523E+09  2.41908E+07  -1.28923E+06  6.98896E+05  4.21836E+05  1.24546E+06  7.19300E+06
0.04000      2.43031D+09  2.39024E+09  2.36692E+07  -1.86555E+06  1.19171E+06  1.17562E+06  1.09362E+06  1.10725E+07
0.05000      2.43033D+09  2.38520E+09  2.31633E+07  -2.40885E+06  1.68450E+06  2.27838E+06  9.13672E+05  1.46822E+07
0.06000      2.43032D+09  2.38001E+09  2.26724E+07  -2.91209E+06  1.98853E+06  2.94219E+06  1.26005E+06  1.85345E+07
0.07000      2.43033D+09  2.37328E+09  2.21996E+07  -3.38520E+06  1.95149E+06  3.40352E+06  2.18614E+06  2.39270E+07
0.08000      2.43035D+09  2.36599E+09  2.17513E+07  -3.83789E+06  1.92903E+06  4.10010E+06  2.71034E+06  3.00339E+07
0.09000      2.43036D+09  2.35913E+09  2.13277E+07  -4.27528E+06  2.32709E+06  5.18614E+06  2.33873E+06  3.57727E+07
0.10000      2.43035D+09  2.35343E+09  2.09247E+07  -4.70094E+06  3.03147E+06  6.02213E+06  2.12123E+06  4.01212E+07
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 3 of 11)

```
TIME HISTORIES OF INTERACTION LOADS


LOAD INTERACTION CURVE NO.   1 , BEAM NO.   1
LOCATION:  FS= 300.000 , BL=   0.0   , WL=   0.0

          CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0             1       1.4436E+03  1.4577E+05  1.0451E-02
 0.01000000      1       1.4504E+03  1.4605E+05  1.0491E-02
 0.02000000      1       1.2069E+03  1.5838E+05  9.5381E-03
 0.03000000      8       4.1270E+01 -1.5247E+04  7.3302E-04
 0.04000000      2       5.8026E+02 -7.8526E+04  4.6380E-03
 0.05000000      5       8.2173E+02 -7.3250E+03  4.9502E-03
 0.06000000      8      -1.2857E+02 -7.0512E+04  3.3900E-03
 0.06999999      1       4.2607E+03  1.9882E+05  2.5770E-02
 0.07999998      7      -5.9770E+03 -1.8445E+05  3.6006E-02
 0.08999997      2       2.8527E+03 -1.8420E+05  1.8375E-02
 0.09999996      8      -9.0519E+02 -1.8431E+05  8.8609E-03

     MAXIMUM VALUE:      4.2607E+03  1.9882E+05  3.6006E-02
     MINIMUM VALUE:     -5.9770E+03 -1.8445E+05


LOAD INTERACTION CURVE NO.   2 , BEAM NO.   2
LOCATION:  FS= 300.000 , BL=   0.0   , WL=   0.0

          CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0             5       1.0824E+04  1.4971E+05  6.5207E-02
 0.01000000      5       1.0887E+04  1.4650E+05  6.5582E-02
 0.02000000      1       7.0437E+03  4.0997E+05  4.4386E-02
 0.03000000      6       3.2861E+01  4.7377E+04  2.2777E-03
 0.04000000      8      -6.8032E+03 -1.3475E+06  6.4784E-02
 0.05000000      7      -2.5080E+04  2.6356E+04  1.5109E-01
 0.06000000      7      -4.6627E+04  5.3843E+05  2.8089E-01
 0.06999999      7      -6.5402E+04 -1.3806E+06  3.9399E-01
 0.07999998      8       2.5365E+02 -6.7244E+06  3.2329E-01
 0.08999997      2       5.0925E+03 -8.4343E+05  4.4086E-02
 0.09999996      1       2.7333E+04  1.7523E+06  1.7578E-01

     MAXIMUM VALUE:      2.7333E+04  1.7523E+06  3.9399E-01
     MINIMUM VALUE:     -6.5402E+04 -6.7244E+06


LOAD INTERACTION CURVE NO.   3 , BEAM NO.   2
LOCATION:  FS= 400.000 , BL=   0.0   , WL=   0.0

          CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0             1       1.0824E+04  1.2341E+06  7.8808E-02
 0.01000000      1       1.0887E+04  1.2371E+06  7.9194E-02
 0.02000000      1       7.0437E+03  1.1156E+06  5.6423E-02
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 4 of 11)

```
 0.03000000     10        3.2861E+01  5.0669E+04  2.1290E-03
 0.04000000      8       -6.8032E+03 -2.0291E+06  8.9975E-02
 0.05000000      5       -2.5080E+04 -2.4863E+06  1.7646E-01
 0.06000000      5       -4.6627E+04 -4.1329E+06  3.2001E-01
 0.06999999      5       -6.5402E+04 -7.9327E+06  4.8400E-01
 0.07999998     12        2.5365E+02 -6.6995E+06  2.8149E-01
 0.08999997      3        5.0925E+03 -3.3379E+05  3.3017E-02
 0.09999996      1        2.7333E+04  4.4902E+06  2.2160E-01

      MAXIMUM VALUE:      2.7333E+04  4.4902E+06  4.8400E-01
      MINIMUM VALUE:     -6.5402E+04 -7.9327E+06


LOAD INTERACTION CURVE NO.   4 , BEAM NO.   3
LOCATION:  FS= 480.000 , BL=   0.0   , WL=   0.0

             CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME        LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0              1       2.3901E+04  2.3626E+06  1.4070E-01
 0.01000000       1       2.3358E+04  2.3918E+06  1.3814E-01
 0.02000000       1       2.0812E+04  1.8557E+06  1.2097E-01
 0.03000000       1       1.7145E+04  1.3405E+05  8.8953E-02
 0.04000000       3       1.7727E+04 -1.8144E+06  1.0483E-01
 0.05000000       6       5.3163E+03 -4.2486E+06  1.5676E-01
 0.06000000       6       1.2085E+04 -7.8305E+06  2.9311E-01
 0.06999999       6       5.4359E+04 -1.0317E+07  4.5667E-01
 0.07999998       6       3.5852E+04 -4.7208E+06  2.2910E-01
 0.08999997       1       3.8774E+04  4.5970E+05  2.0237E-01
 0.09999996       2       5.1361E+04  7.1999E+06  3.4332E-01

      MAXIMUM VALUE:      5.4359E+04  7.1999E+06  4.5667E-01
      MINIMUM VALUE:      0.0        -1.0317E+07


LOAD INTERACTION CURVE NO.   5 , BEAM NO.   3
LOCATION:  FS= 540.000 , BL=   0.0   , WL=   0.0

             CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME        LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0              1       2.3901E+04  3.7968E+06  1.4776E-01
 0.01000000       1       2.3358E+04  3.7935E+06  1.4501E-01
 0.02000000       1       2.0812E+04  3.1045E+06  1.2719E-01
 0.03000000       1       1.7145E+04  1.1629E+06  9.4626E-02
 0.04000000       3       1.7727E+04 -7.5068E+05  9.4545E-02
 0.05000000       6       5.3163E+03 -3.9297E+06  1.1522E-01
 0.06000000       6       1.2085E+04 -7.1054E+06  2.1014E-01
 0.06999999       3       5.4359E+04 -7.0553E+06  3.2455E-01
 0.07999998       3       3.5852E+04 -2.5696E+06  1.9888E-01
 0.08999997       1       3.8774E+04  2.7860E+06  2.1514E-01
 0.09999996       1       5.1361E+04  1.0282E+07  3.3298E-01

      MAXIMUM VALUE:      5.4359E+04  1.0282E+07  3.3298E-01
      MINIMUM VALUE:      0.0        -7.1054E+06


LOAD INTERACTION CURVE NO.   6 , BEAM NO.   3
LOCATION:  FS= 620.000 , BL=   0.0   , WL=   0.0
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 5 of 11)

```
                CRITICAL LOAD  X LOAD       Y LOAD     MAX. LOAD
 TIME            LINE NUMBER   (NO. 3)      (NO. 5)      RATIO

0.0                  2        2.3901E+04  5.7091E+06  1.3381E-01
0.01000000           2        2.3358E+04  5.6624E+06  1.3181E-01
0.02000000           2        2.0812E+04  4.7697E+06  1.1399E-01
0.03000000           2        1.7145E+04  2.5347E+06  7.6405E-02
0.04000000           1        1.7727E+04  6.6760E+05  6.5578E-02
0.05000000          12        5.3163E+03 -3.5045E+06  7.7877E-02
0.06000000          12        1.2085E+04 -6.1387E+06  1.3641E-01
0.06999999           3        5.4359E+04 -2.7066E+06  2.0465E-01
0.07999998           9        3.5852E+04  2.9856E+05  1.3085E-01
0.08999997           2        3.8774E+04  5.8878E+06  1.7474E-01
0.09999996          10        5.1361E+04  1.4391E+07  3.1979E-01

     MAXIMUM VALUE:           5.4359E+04  1.4391E+07  3.1979E-01
     MINIMUM VALUE:           0.0        -6.1387E+06


LOAD INTERACTION CURVE NO.   7 , BEAM NO.   4
LOCATION:  FS= 620.000 , BL=   0.0   , WL=   0.0

                CRITICAL LOAD  X LOAD       Y LOAD     MAX. LOAD
 TIME            LINE NUMBER   (NO. 3)      (NO. 5)      RATIO

0.0                  2        3.1956E+04  5.7088E+06  1.5476E-01
0.01000000           2        3.2378E+04  5.5424E+06  1.5377E-01
0.02000000           1        3.9180E+04  4.3800E+06  1.6059E-01
0.03000000           1        4.5518E+04  2.3272E+06  1.7169E-01
0.04000000           9        3.4936E+04  5.9865E+05  1.2750E-01
0.05000000           3        5.8597E+04 -3.8165E+06  2.2545E-01
0.06000000           3        1.0030E+05 -6.3104E+06  3.8470E-01
0.06999999           9        1.0682E+05 -2.3249E+06  3.8985E-01
0.07999998           9        1.0936E+05 -6.6178E+05  3.9914E-01
0.08999997           1        1.1516E+05  5.6730E+06  4.3322E-01
0.09999996           2        8.7665E+04  1.3921E+07  4.0273E-01

     MAXIMUM VALUE:           1.1516E+05  1.3921E+07  4.3322E-01
     MINIMUM VALUE:           0.0        -6.3104E+06


LOAD INTERACTION CURVE NO.   8 , BEAM NO.   5
LOCATION:  FS= 960.000 , BL=   0.0   , WL=   0.0

                CRITICAL LOAD  X LOAD       Y LOAD     MAX. LOAD
 TIME            LINE NUMBER   (NO. 3)      (NO. 5)      RATIO

0.0                  1        2.6029E+04  1.3903E+07  1.8948E-01
0.01000000           1        3.3438E+04  1.3620E+07  1.8410E-01
0.02000000           7        7.7627E+04  1.3860E+07  2.6954E-01
0.03000000           7        1.4105E+05  1.9478E+07  4.8975E-01
0.04000000           2        1.4238E+05  3.0446E+07  4.9932E-01
0.05000000           2        1.7177E+05  3.6875E+07  6.0333E-01
0.06000000           7        2.2831E+05  4.1785E+07  7.9275E-01
0.06999999           2        1.9131E+05  4.7063E+07  7.1118E-01
0.07999998           1        8.7044E+04  5.3087E+07  7.2583E-01
0.08999997           1        1.5296E+05  5.0584E+07  6.7823E-01
0.09999996           2        2.4960E+05  5.6226E+07  8.9400E-01

     MAXIMUM VALUE:           2.4960E+05  5.6226E+07  8.9400E-01
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 6 of 11)

```
      MINIMUM VALUE:     0.0          0.0


LOAD INTERACTION CURVE NO.   9 , BEAM NO.   6
LOCATION:  FS= 960.000 , BL=   0.0   , WL=   0.0

            CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME        LINE NUMBER  (NO. 3)     (NO. 5)     RATIO

 0.0              1       3.9299E+04  1.4143E+07  1.9029E-01
 0.01000000       1       4.1317E+04  1.4114E+07  1.8950E-01
 0.02000000       2       6.3622E+04  1.4524E+07  2.2913E-01
 0.03000000       7       1.1614E+05  1.9357E+07  4.0326E-01
 0.04000000       7       1.4935E+05  3.0596E+07  5.1859E-01
 0.05000000       2       1.6815E+05  3.8531E+07  6.0653E-01
 0.06000000       2       2.0004E+05  4.2754E+07  7.0138E-01
 0.06999999       2       1.7822E+05  4.8462E+07  6.9276E-01
 0.07999998       1       1.1828E+05  5.6003E+07  7.6065E-01
 0.08999997       1       1.2390E+05  5.3240E+07  7.2094E-01
 0.09999996       2       1.9407E+05  5.8359E+07  7.9092E-01

      MAXIMUM VALUE:     2.0004E+05  5.8359E+07  7.9092E-01
      MINIMUM VALUE:     0.0         0.0


LOAD INTERACTION CURVE NO.  10 , BEAM NO.   6
LOCATION:  FS=1000.000 , BL=   0.0   , WL=   0.0

            CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME        LINE NUMBER  (NO. 3)     (NO. 5)     RATIO

 0.0              1       3.9299E+04  1.2568E+07  1.8552E-01
 0.01000000       1       4.1317E+04  1.2459E+07  1.9174E-01
 0.02000000       1       6.3622E+04  1.1974E+07  2.6373E-01
 0.03000000       9       1.1614E+05  1.4703E+07  4.5724E-01
 0.04000000       1       1.4935E+05  2.4612E+07  6.0381E-01
 0.05000000       1       1.6815E+05  3.1794E+07  6.9765E-01
 0.06000000       1       2.0004E+05  3.4739E+07  8.1648E-01
 0.06999999       1       1.7822E+05  4.1321E+07  7.7277E-01
 0.07999998       2       1.1828E+05  5.1263E+07  6.9592E-01
 0.08999997       2       1.2390E+05  4.8276E+07  6.6458E-01
 0.09999996       1       1.9407E+05  5.0583E+07  8.6592E-01

      MAXIMUM VALUE:     2.0004E+05  5.1263E+07  8.6592E-01
      MINIMUM VALUE:     0.0         0.0


LOAD INTERACTION CURVE NO.  11 , BEAM NO.   7
LOCATION:  FS=1080.000 , BL=   0.0   , WL=   0.0

            CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
 TIME        LINE NUMBER  (NO. 3)     (NO. 5)     RATIO

 0.0              3       2.3984E+04  1.0029E+07  1.7194E-01
 0.01000000       3       2.3995E+04  1.0004E+07  1.7155E-01
 0.02000000       2       2.5504E+04  9.0995E+06  1.6228E-01
 0.03000000       2       4.5198E+04  8.5146E+06  2.1695E-01
 0.04000000       2       8.9251E+04  1.4050E+07  4.0275E-01
 0.05000000       2       1.0990E+05  2.0777E+07  5.2819E-01
 0.06000000       2       1.0782E+05  2.1828E+07  5.3159E-01
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 7 of 11)

```
 0.06999999        2          1.0645E+05  2.9461E+07  5.9826E-01
 0.07999998        2          1.1290E+05  4.1935E+07  7.3371E-01
 0.08999997        3          8.0235E+04  4.3049E+07  7.2362E-01
 0.09999996        3          9.6245E+04  3.9365E+07  6.7623E-01

      MAXIMUM VALUE:          1.1290E+05  4.3049E+07  7.3371E-01
      MINIMUM VALUE:          0.0         0.0


LOAD INTERACTION CURVE NO.  12 , BEAM NO.   7
LOCATION:  FS=1160.000 , BL=   0.0    , WL=   0.0

           CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0               3          2.3984E+04  8.0997E+06  1.9212E-01
 0.01000000        3          2.3995E+04  8.0736E+06  1.9161E-01
 0.02000000        3          2.5504E+04  7.0481E+06  1.7293E-01
 0.03000000        2          4.5198E+04  4.8792E+06  1.7986E-01
 0.04000000        1          8.9251E+04  6.8714E+06  3.4757E-01
 0.05000000        2          1.0990E+05  1.1939E+07  4.3823E-01
 0.06000000        2          1.0782E+05  1.3156E+07  4.4723E-01
 0.06999999        3          1.0645E+05  2.0900E+07  5.5110E-01
 0.07999998        3          1.1290E+05  3.2855E+07  7.9869E-01
 0.08999997        3          8.0235E+04  3.6596E+07  8.3308E-01
 0.09999996        3          9.6245E+04  3.1624E+07  7.5333E-01

      MAXIMUM VALUE:          1.1290E+05  3.6596E+07  8.3308E-01
      MINIMUM VALUE:          0.0         0.0


LOAD INTERACTION CURVE NO.  13 , BEAM NO.   8
LOCATION:  FS=1240.000 , BL=   0.0    , WL=   0.0

           CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0              12          9.1586E+03  6.7597E+06  1.9314E-01
 0.01000000       12          9.1267E+03  6.7581E+06  1.9309E-01
 0.02000000       12          6.9134E+03  6.5027E+06  1.8579E-01
 0.03000000       12          9.6961E+02  4.6879E+06  1.3394E-01
 0.04000000        2          1.1809E+04  2.2847E+06  7.4081E-02
 0.05000000        2          3.3667E+04  4.2377E+06  1.6614E-01
 0.06000000        3          2.0969E+04  9.4567E+06  2.7731E-01
 0.06999999        3          4.1532E+04  1.6141E+07  4.7927E-01
 0.07999998        3          7.7620E+04  2.2334E+07  6.8404E-01
 0.08999997        3          7.9260E+04  2.9386E+07  8.7635E-01
 0.09999996        3          4.9596E+04  3.0264E+07  8.6933E-01

      MAXIMUM VALUE:          7.9260E+04  3.0264E+07  8.7635E-01
      MINIMUM VALUE:          0.0         0.0


LOAD INTERACTION CURVE NO.  14 , BEAM NO.   8
LOCATION:  FS=1320.000 , BL=   0.0    , WL=   0.0

           CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME      LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0               8          9.1586E+03  6.0106E+06  2.2098E-01
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 8 of 11)

```
 0.01000000       8       9.1267E+03  6.0116E+06  2.2101E-01
 0.02000000       8       6.9134E+03  5.9372E+06  2.1828E-01
 0.03000000       8       9.6961E+02  4.6086E+06  1.6943E-01
 0.04000000       1       1.1809E+04  1.3188E+06  6.5427E-02
 0.05000000       1       3.3667E+04  1.4842E+06  2.1132E-01
 0.06000000       8       2.0969E+04  7.7417E+06  2.8462E-01
 0.06999999       8       4.1532E+04  1.2744E+07  4.6854E-01
 0.07999998       2       7.7620E+04  1.5986E+07  6.1986E-01
 0.08999997       8       7.9260E+04  2.2904E+07  8.4206E-01
 0.09999996       8       4.9596E+04  2.6208E+07  9.6353E-01

      MAXIMUM VALUE:      7.9260E+04  2.6208E+07  9.6353E-01
      MINIMUM VALUE:      0.0         0.0


LOAD INTERACTION CURVE NO.  15 , BEAM NO.   9
LOCATION:  FS=1400.000 , BL=   0.0   , WL=   0.0

          CRITICAL LOAD  X LOAD      Y LOAD    MAX. LOAD
  TIME     LINE NUMBER   (NO. 3)     (NO. 5)     RATIO

 0.0              3       2.3091E+04  4.0093E+06  2.3738E-01
 0.01000000       3       2.3090E+04  4.0089E+06  2.3736E-01
 0.02000000       3       2.2937E+04  4.0195E+06  2.3775E-01
 0.03000000       3       1.8054E+04  3.3308E+06  1.9598E-01
 0.04000000       1       8.2389E+03  3.4136E+05  6.0505E-02
 0.05000000       1       1.2675E+04 -6.3078E+05  1.1410E-01
 0.06000000       3       3.0582E+04  5.6778E+06  3.3385E-01
 0.06999999       3       4.8597E+04  8.9195E+06  5.2507E-01
 0.07999998       3       6.1157E+04  1.0004E+07  5.9621E-01
 0.08999997       3       8.3528E+04  1.5607E+07  9.1709E-01
 0.09999996       3       8.9178E+04  2.0268E+07  1.1699E+00

      MAXIMUM VALUE:      8.9178E+04  2.0268E+07  1.1699E+00
      MINIMUM VALUE:      0.0        -6.3078E+05


SUMMARY OF MAXIMUM LOAD RATIOS

INTERACTION   BEAM     INT. CURVE LOCATION          MAXIMUM
 CURVE NO.     NO.    FS          BL          WL      LOAD RATIO

      1         1   300.000      0.0         0.0       3.6006E-02
      2         2   300.000      0.0         0.0       3.9399E-01
      3         2   400.000      0.0         0.0       4.8400E-01
      4         3   480.000      0.0         0.0       4.5667E-01
      5         3   540.000      0.0         0.0       3.3298E-01
      6         3   620.000      0.0         0.0       3.1979E-01
      7         4   620.000      0.0         0.0       4.3322E-01
      8         5   960.000      0.0         0.0       8.9400E-01
      9         6   960.000      0.0         0.0       7.9092E-01
     10         6  1000.000      0.0         0.0       8.6592E-01
     11         7  1080.000      0.0         0.0       7.3371E-01
     12         7  1160.000      0.0         0.0       8.3308E-01
     13         8  1240.000      0.0         0.0       8.7635E-01
     14         8  1320.000      0.0         0.0       9.6353E-01
     15         9  1400.000      0.0         0.0       1.1699E+00

OVERALL MAXIMUM LOAD RATIO =    1.1699E+00
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 9 of 11)

```
CORRESPONDING INT. CURVE NO.= 15
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 10 of 11)

```
TIME HISTORIES OF VEHICLE CG MOTIONS

 TIME              DXI            DYI              DZI             FXI             FYI               FZI
                   VXI            VYI              VZI             AXI             AYI               AZI

0.0               0.0            0.0              0.0              3.97904D-13    0.0              -1.63709D-11
                  3.14000D+03    0.0              3.00000D+02     -9.88461D-03    0.0               2.21053D-02

0.010000          3.13976D+01    0.0              2.99302D+00      5.96861D+04    0.0               1.98954D+05
                  3.13932D+03    0.0              2.97963D+02     -3.30718D-01    0.0              -1.04434D+00

0.020000          6.27826D+01    0.0              5.94653D+00      1.05983D+05    0.0               3.53277D+05
                  3.13753D+03    0.0              2.92227D+02     -5.79321D-01    0.0              -1.87156D+00

0.030000          9.41457D+01    0.0              8.82912D+00      1.29544D+05    0.0               4.31816D+05
                  3.13501D+03    0.0              2.84048D+02     -7.05133D-01    0.0              -2.29257D+00

0.040000          1.25482D+02    0.0              1.16250D+01      1.23940D+05    0.0               4.13133D+05
                  3.13230D+03    0.0              2.75235D+02     -6.73781D-01    0.0              -2.19246D+00

0.050000          1.56793D+02    0.0              1.43366D+01      1.13817D+05    0.0               3.79396D+05
                  3.12984D+03    0.0              2.67220D+02     -6.17434D-01    0.0              -2.01165D+00

0.060000          1.88079D+02    0.0              1.69683D+01      1.36810D+05    0.0               4.56036D+05
                  3.12729D+03    0.0              2.58889D+02     -7.38212D-01    0.0              -2.42251D+00

0.070000          2.19335D+02    0.0              1.95022D+01      2.02074D+05    0.0               6.73580D+05
                  3.12373D+03    0.0              2.47167D+02     -1.08618D+00    0.0              -3.58865D+00

0.080000          2.50551D+02    0.0              2.19053D+01      1.98194D+05    0.0               6.60648D+05
                  3.11965D+03    0.0              2.33676D+02     -1.06490D+00    0.0              -3.51937D+00

0.090000          2.81728D+02    0.0              2.41760D+01      1.60565D+05    0.0               5.35217D+05
                  3.11580D+03    0.0              2.20964D+02     -8.63368D-01    0.0              -2.84706D+00

0.100000          3.12871D+02    0.0              2.63361D+01      1.34529D+05    0.0               4.48435D+05
                  3.11290D+03    0.0              2.11426D+02     -7.23725D-01    0.0              -2.38189D+00
```

Figure 2-25. KRASH85 Summary Output Data (Sheet 11 of 11)

SUMMARY OF INTERNAL BEAM YIELDING AND RUPTURE, the first item for beam 18 is a conventional beam yielding in the 1, or axial direction. The second item, for beam 19, is a conventional beam rupture due to exceeding input maximum load levels, again in the axial direction. The third line, for beam 9, is an example of load interaction curve data showing up in this summary. The 15 under YIELD signifies that for load interaction curve number 15, an exceedance of the defined load envelope has occurred. The 3 in the right hand column means that load line number 3, for interaction curve 15, was the specific interaction line that was exceeded. If the input load envelope is exceeded by the factor RUPRAT (See Section 2.2, figure 2-3, card 2800), then the load interaction curve number will be printed under the heading RUPTURE. It should be noted that load interaction curve outputs in the YIELD column have caused nothing to happen in the time history solution; outputs in the RUPTURE column would have triggered an actual beam rupture during the time history solution.

Any mass penetrations into the mass penetration control volume are also summarized. Both the mass penetrating the control volume and time of occurrence are noted. Since MVP = 0 in the sample case, this output is not illustrated in figure 2-25.

The summary of external spring loading and unloading provides the time of occurrence, the spring designations (mass, node, direction), type of event, initial deflection, maximum force and unloaded deflection and force.

The summary of plastic hinge formations identifies the time, beam number and mass number at the end where a plastic hinge formation takes place. In figure 2-25, beam 1 and mass 2 goes through cyclic plastic hinge motion. At t = .0616, NEWPIN = 1 signifies that the coding has changed from fixed at the j end to pinned at the j end (j = 2). This is the technique for forming a plastic hinge. At t = .0643, NEWPIN = 0 signifies that unloading has occurred, so that a fixed end condition is appropriate. Subsequent changes in NEWPIN define transition points on a hysteresis curve. NEWPIN = 0 always means a transition to fixed coding has taken place, due to unloading from a plastic hinge moment. NEWPIN = 1 always means that a transition to pinned coding has taken place, due to exceeding the input plastic hinge moment. DIRECTION = 5 in figure 2-23 refers to moments about the y beam axis (6 would be moment about the z beam axis). DIRECTION = -5 means that the sign of the plastic hinge moment at that time is negative.

The energy summaries showing the time variation of the different types of energy are presented. These summaries faciliatate visualizing the energy flow time variation; the two summaries are much easier to read than skimming through the basic time history print, which can run to hundreds of pages. Figure 2-25 shows an example of this output for the sample case. A quick glance at the "PERCENT TEMPORAL ENERGY DISTRIBUTION SUMMARY" tells the user how stable the solution is. The percent energy should stay within 99-101 percent, preferably within a ±0.2 percent band. Any significant system instabilities will quickly manifest themselves in this output.

The column entitled "PERCENT MAXIMUM MASS DEVIATION" shows the maximum deviation from 100 percent of the total energy for each mass individually, i.e., at each time the worst deviation of all the masses is shown/ These numbers will always indicate a greater departure from 100 percent than the "PERCENT TOTAL SYSTEM ENERGY" column, wherein all the masses constituting the system are included. The reason for this situation is that some of the masses have positive and some negative deviations from 100 percent, and when these are summed over the total system, cancellations occur. Individual mass total energy deviations in the order of 10 percent may be tolerable, as long as the total system energy is acceptable. In the example shown in figure 2-25, the total system energy remains constant within .01 percent, while the maximum energy deviation is .02 percent at the conclusion of the analysis.

Time histories of interaction loads follow the energy summary. In the sample case, there are 15 of these time histories, requiring about 5½ pages of output. For each load interaction curve number, the following information is presented versus time:

- X load value, pounds or inch-pounds
- Y load value, pounds or inch-pounds

- Critical load line number. Of all the straight line segments making up the load envelope, the one which is most critical relative to the current X,Y combined loads is indicated. In general, the critical load line number will change with time as the X and Y loads change.
- Maximum load ratio. This is the ratio by which the current load vector length (pt. 0,0 to point X,Y) exceeds a line along this vector but terminating at the intersection of the vector and the critical load line (input). A ratio greater than 1.0 signifies an excursion outside the load envelope defined in the input data.

Each time history data block also includes the identification of the load interaction curve number, beam number and location (FS, BL and WL). Also, the directions of the X and Y loads are defined. In the sample case, the X load is always 3 (vertical shear, Fz) and the Y load is always 5 (bending moment about 7 axis). At the end of each time history data block, the maximum and minimum values of X load and Y load are shown, as well as the peak value of MAX.LOAD RATIO.

After the individual load interaction time histories, a summary of the peak values of the maximum load ratio is shown for all the input curves. This is followed by the overall maximum load ratio and the corresponding interaction curve number. For example, in figure 2-25, the overall maximum load ratio is 1.1699, which occurs for interaction curve number 15. This output gives a very quick indication of the severity of the impact being analyzed. However, maximum load ratios greater than 1.0 do not necessarily imply that the corresponding structural section would have completely failed. Refer to Section 3.1 for a discussion of the theory and usage of the load-interaction data.

If the interaction curves are used to obtain an overall section shear and moment (summation of all loads acting at a particular station) then the aforementioned printed summary is applicable to the sum of the forces acting and not an individual beam.

The final summary print output is a time history of the overall vehicle c.g. motions. The quantities included are

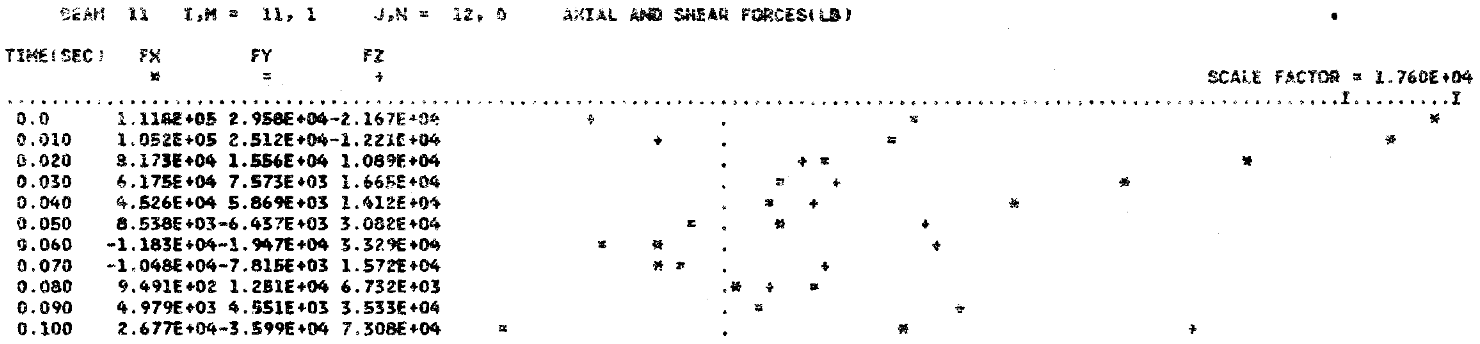
- c.g. translational accelerations, g's
- c.g. translational velocities, in/sec
- c.g. translational displacements, in (= 0 at time = 0)
- Net forces acting at the c.g., pounds

All these data are calculated in the same manner as the c.g. translational velocities, described in Section 1.3.9 of Volume I. Weighted averages of all the mass motions are used to arrive at a value for the entire system. The final results completely define the translational motions of an uncoupled 1-mass, 3 degree-of-freedom system. Rotational loads and motions are not presented.

These data have been used to determine vertical load-deflection characteristics for a large transport frame structure. Cross plots of DZI vs FZI from the KRASH analysis of a frame structure form a load-deflection curve that can be used to determine the external spring characteristics of a stick model of an entire airplane.

2.3.3.4 Time History Plots

The final section of output data consists of time history plots of selected response quantities. Figure 2-26 illustrates typical output data. The sequential time history print of the three responses is shown on the left, while the plots are generated using three separate printer symbols. The scale factor for all three plots is shown in the upper right corner of the page. The plot summary is printed on a separate output page as are the various sets of data.



```
     BEAM  11   I,M =  11, 1     J,N =  12, 0     AXIAL AND SHEAR FORCES(LB)
TIME(SEC)   FX        FY        FZ
             *         =         +                                                                         SCALE FACTOR = 1.760E+04
........................................................................................................................I.........I
 0.0      1.118E+05 2.958E+04-2.167E+04             +           .                =                                              *
 0.010    1.052E+05 2.512E+04-1.221E+04                   +     .              =                                            *
 0.020    8.173E+04 1.556E+04 1.089E+04                         .      + =                                     *
 0.030    6.175E+04 7.573E+03 1.665E+04                         .    =    +                         *
 0.040    4.526E+04 5.869E+03 1.612E+04                         .   =   +                 *
 0.050    8.538E+03-6.437E+03 3.082E+04                      =  .    *            +
 0.060   -1.183E+04-1.947E+04 3.329E+04              =    *     .                  +
 0.070   -1.048E+04-7.815E+03 1.572E+04                   * =   .        +
 0.080    9.491E+02 1.281E+04 6.732E+03                         .*  +   =
 0.090    4.979E+03 4.551E+03 3.533E+04                         .  *                 +
 0.100    2.677E+04-3.599E+04 7.308E+04     =                   .               *                         +
```

Figure 2-26. KRASH85 Sample Output Time History Plots

SECTION 3

ADDITIONAL KRASH85 DATA REQUIREMENTS

This sections contains a description of those KRASH data requirements that are needed for KRASH85. These requirements are in addition to those items provided in Section 4 of reference 2.

3.1 LOAD-INTERACTION CURVES

KRASH85 has provisions to include load interaction curve data for failure prediction. Figure 3-1 shows a typical set of interaction curves for fuselage bending and shear at a particular airplane fuselage station. Figure 3-2 identifies the stringers at a representative frame location. The input requirements for load-interaction curves are as follows:

- The user can specify interaction curves at a maximum of 40 locations, which can be anywhere. For each curve, either a Fuselage Station, Butt Line, or Water Line (only one) is input, as well as the corresponding beam number in a KRASH model. The location of the interaction curve can be anywhere along a given beam; the user is not restricted to using the end points of the beam. For essentially fore-aft beams, only F.S. is input, while for lateral and vertical beams B.L. and W.L., respectively, are input to define the location of a load interaction curve. For each load interaction curve, the user inputs the following additional information:
    - The two load directions for the interaction curve. In figure 3-1, the abscissa represents vertical shear (direction 3) and the ordinate represents vertical bending moment (direction 5). Any 2 of the 6 loads can be specified.
    - A user-specified load sign convention.
    - Horizontal and vertical load interaction lines (4 total).

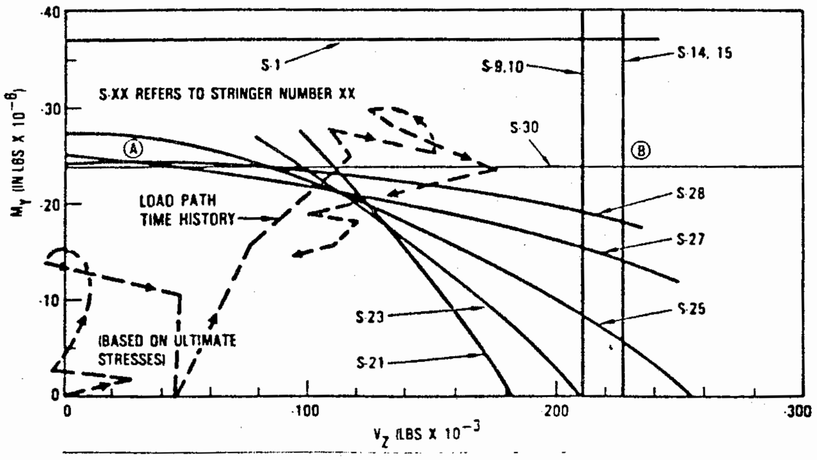


FIGURE 3-1. MAXIMUM ALLOWABLE MOMENT AND SHEAR ENVELOPE - NEGATIVE BENDING

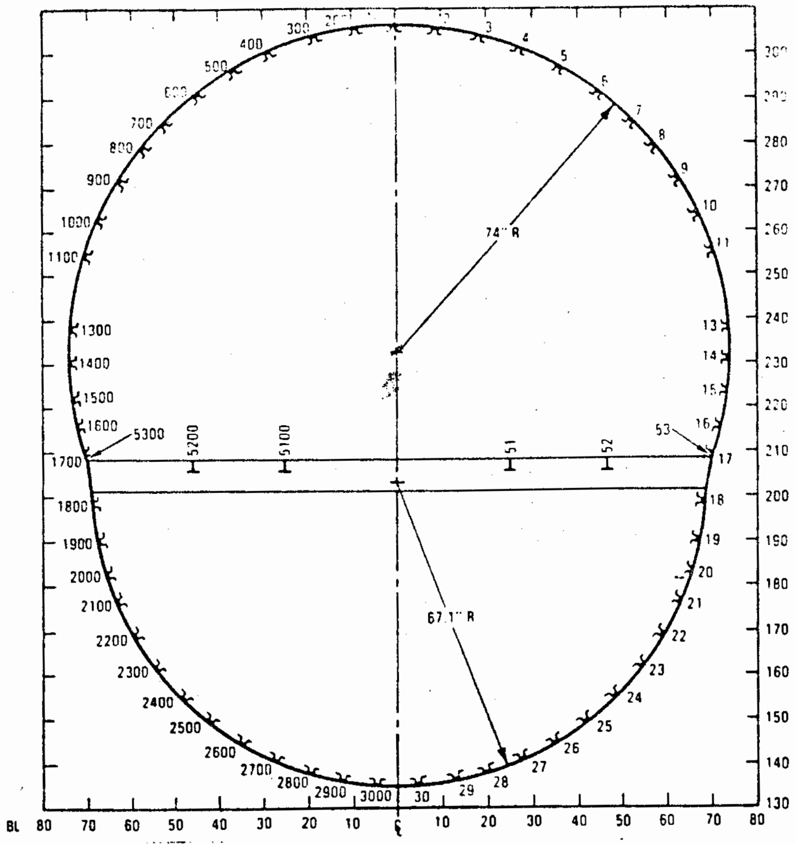


FIGURE 3-2. TYPICAL CROSS SECTION WITH STIFFENER LOCATIONS - REAR VIEW

- Up to 20 straight, sloping load interaction lines. The x and y axis intercepts are input for each line.
- A quantity called RUPRAT (rupture ratio), which is explained below.

The program is coded so that for the sloping interaction lines, data are input for any one quadrant (x and y axis intercepts). In addition, "mirror flags" are input to tell the program whether or not to generate mirror image lines about the x and/or y axes. For example, in figure 3-3 the data are input for line 1 (x and y intercepts), and both the x and y axis mirror flags are input as 1. The program then automatically generates lines 2, 3, and 4. If only a mirror about the y axis had been specified, then the program would generate only line 2.

At each location the program calculates the following:

- The internal beam loads, in KRASH sign convention, at the load interaction point.
  - These loads are transformed to correspond to the standard structural load sign convention employed by the Lockheed-California Company (Calac), shown in figure 3-4.
  - The Calac-convention loads are then transformed to a user-specified sign convention. One of ten such sign conventions may be selected by the user. If no convention is specified, the loads are left in the Calac sign convention.
  - The two interaction loads are selected from the 6 loads calculated.
- A load ratio for each load interaction line. A ratio greater than one indicates that a load interaction curve has been exceeded, signifying that at least one element has failed in some manner. KRASH is coded to allow complete rupture of a beam element if an input maximum load ratio (RUPRAT) is exceeded.

  1. A left handed coordinate system is used; moments employ left hand rule.
  2. Internal loads and moments are positive if the loads or moments applied by the part with the greater algebraic coordinate are positive in accordance with body axes conventions shown as x, y, z.

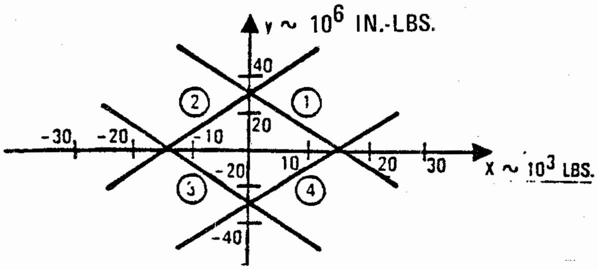


FIGURE 3-3. GENERATION OF LOAD-INTERACTION CURVES

Application of these rules to fuselage and wing loads are shown in the following sketch:

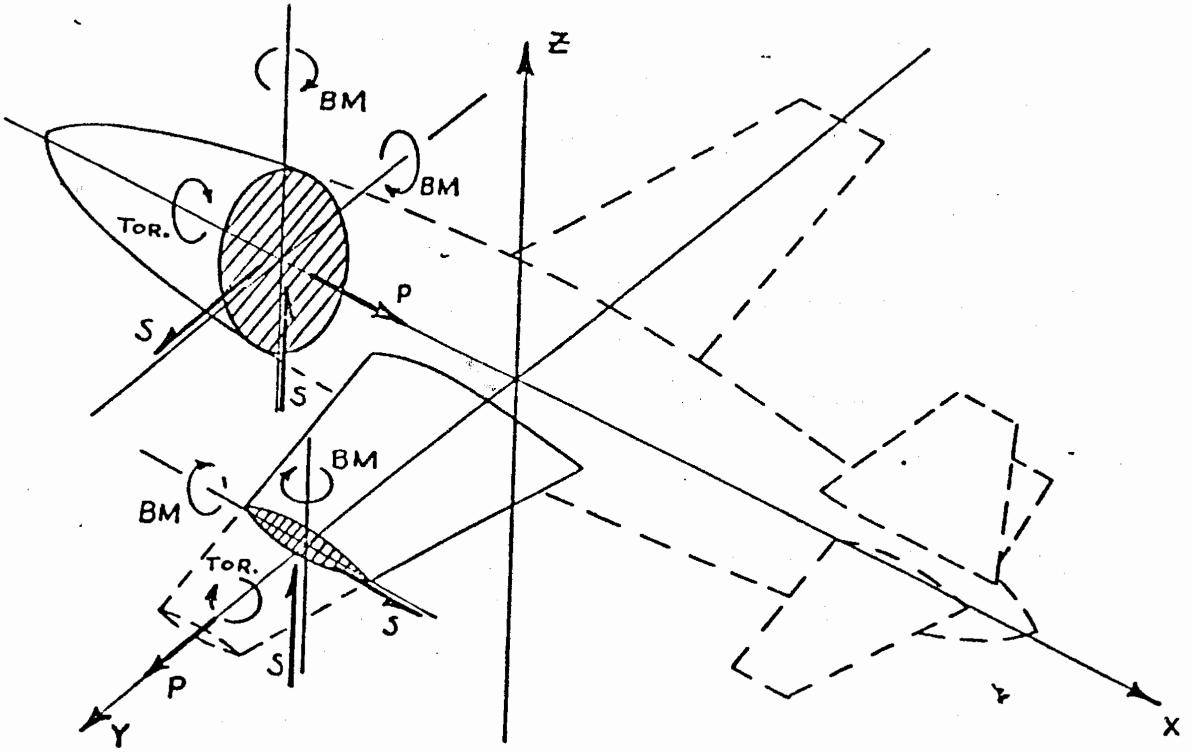


FIGURE 3-4. LOCKHEED LOAD SIGN CONVENTIONS

Loads shown are those applied to the cutplane by the parts with the greater algobraic coordinate (station).

At the conclusion of the computer run the following is printed:

- Time histories of the following quantities for each load interaction curve.
    - X Load (fuselage vertical shear in figure 3-1).
    - Y Load (fuselage vertical bending in figure 3-1).
    - Maximum load ratio at each time.
    - Input load interaction line number corresponding to the maximum load ratio at that time.
- A summary which shows the peak maximum load ratio for each interaction curve and the overall maximum load ratio.

The user has the option of saving the load-interaction curve time history data in an output file, which can be used for subsequent post-processing. These data can be plotted to show the time-varying path of the calculated x-y loads, superimposed on the load-interaction curve (as illustrated by the dashed lines in figure 3-1).

While the load interaction data output provides a great deal of useful information not previously available, considerable caution must be exercised by the user in its interpretation. A maximum load ratio greater than one does not, by itself, indicate complete failure of the corresponding fuselage section. The output data have been used in conjunction with the actual manufacturer-furnished interaction diagrams to assess the extent of damage at each location. For example, suppose that the computed combined loads were as shown by points A or B in figure 3-1. For point A stringers S27 through S30 could fail. For point B several additional stringer elements could fail (S-9 through S-15 and S-21 through S-30). Usually the input data to KRASH is the minimum necessary to define the inner boundary in figure 3-1. The current KRASH85 coding does not define which stringers fail; it only defines the critical load line at each time out.

3.2 ARBITRARY MASS NUMBERING

Program KRASH has been modified to accept user supplied mass point identification numbers. The modification can be thought of conceptually as a mass point number pre-processor and a mass point number post-processor. The pre-processor converts external mass point numbers to internal mass point numbers. The external mass point numbers are supplied by the user as part of the input while the internal mass point numbers are defined by the program. The internal mass numbers are consistent with the numbering system previously used in earlier versions of program KRASH. After conversion program KRASH85 is executed using the internal mass point numbers. After execution is completed the post-processor converts the internal mass point numbers to external mass point numbers for output. In the modification, two new subroutines (INPT and INPTPL) were added. In these subroutines, two arrays (MASS and IMASS) are defined which cross reference the external mass point numbers to internal mass point numbers and vice versa.

The external mass point identification numbers are input in column 71 and 72 on Card 200 (MASS POINT DATA). The identification numbers can not be less than zero or greater than 99. If they are, program execution will be halted. If any of the numbers are left blank or set equal to zero, the program will automatically assign sequential identification numbers to all mass points in the order of input. This option accommodates previously developed input data sets.

When the RUNMOD=2 option is used, the program automatically assigns an external mass point identification number to the image mass point generated under this option. The identification number assigned is 100 greater than the identification number of the mass point used in defining the image mass point. For example, if the input mass point identification number is 96 then the image mass point identification number will be 196.

SECTION 4

COMMON BLOCK REGIONS

KRASH85 is designed such that data storage and transfer is accomplished using the many common block regions defined within the program. A cross reference of the common block names and using subroutines is given in Table 4-1. Included in the cross reference summary are size requirements defined by the FORTRAN H/EXTENDED (OPT = 3) compiler.

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE

SUBROUTINE		ACCELT	ACCEN	BEAM	CFORCE	DERTV	DOAIJ	GENMOD	IC	ICINPT	INPRNT	INPRT1	INPT	INPTPL	INPUT	INTERP	KVB	LTCALC	MAIN	MODXDP	NETFOR	PREPLT	PRINT	RSIN	RSOUT	SMLOAD
COMMON REGION	REGION SIZE																									
ACCEDE	30		*			*																				
ACCEIR	280		*			*					*															
ACCSAV	C8F4			*		*		*			*				*			*	*							
ACCSV1	10			*		*		*			*				*			*	*							
AERO1	104C			*		*		*			*				*			*					*			
AERO2	F00			*		*												*					*			
AFENER	280		*			*													*					*	*	
AIJIC	4						*												*							
AVDF	28A4			*		*												*	*							
AVDFRS	780					*																		*	*	
BEAMDE	4210			*		*			*									*	*					*	*	
BKMOD	4			*											*											
BLANK	9980			*		*												*	*		*			*	*	
BOMB	4														*				*							
CFIC	58				*				*												*					
CFINPU	140				*			*			*				*											
CFIP	640				*						*															
CFPR	B40				*																		*	*	*	
COMALL	1C088		*	*	*	*	*	*	*		*				*		*	*	*	*	*		*	*	*	*
COMMI2	8D4							*			*				*		*									
COMMI4	938							*			*				*		*		*	*	*			*	*	
COMMR4	2FD0							*			*				*											
COMMR8	4B0							*			*				*											
COMNEW	18							*	*		*				*		*		*							
DEIC	260			*		*			*									*			*		*			*
DEIN	1022C		*	*		*		*			*				*			*			*		*	*	*	
DEINPR	48B0			*		*	*	*	*		*				*		*	*			*		*			
DEIR	12C0			*		*					*							*								
DEMA	8			*		*												*					*			
DEPR	67B0			*		*												*					*	*	*	
DINICP	2044			*		*		*	*		*	*			*		*	*			*		*	*	*	
DOIN	4B0			*		*	*	*			*				*		*	*								
DRIFLG	140								*												*		*			
DRIMAS	140			*		*					*							*								
ENERGY	16B8			*		*												*					*	*	*	
FBPLT	C8														*							*	*			
FLGSET	5C			*		*													*							
FSIJIJ	3840			*																			*	*	*	*
GRASAV	8			*		*									*			*	*							

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE (CONTINUED)

SUBROUTINE COMMON REGION	SIZE	ACCELT	ACCEN	BEAM	CFORCE	DFRTV	DOAIJ	GENMOD	TC	TCINPT	TNPRNT	TNPRT1	TNPT	TNPTPL	TNPUT	INTERP	KVB	LTCALC	MAIN	MODXDP	NETFOR	PREPLT	PRINT	RSIN	RSOUT	SMLOAD
IBALL	50										*				*											
ICDFLG	8			*							*				*				*							
ICDX	13B0							*	*	*	*								*	*						
ICNETF	F48								*								*		*		*					
INAC	A284	*						*			*		*		*	*										
INCF	DC8				*			*			*				*											
INCFIC	8				*			*	*		*				*						*					
INDEAC	4	*		*		*		*			*				*			*			*					
INIC	CD8			*		*	*	*	*		*				*		*	*		*	*					*
INIDCP	280		*	*	*	*	*	*	*		*				*		*	*		*	*		*			*
ININPR	24										*				*								*			
INOUT	E										*				*								*			
INPR	8			*	*	*		*	*		*				*			*	*		*		*	*	*	
IPIC	4								*		*				*						*					
IRDE	8			*		*					*							*								
IUNAST	4														*		*									
KRUL	1E00			*															*					*	*	
LIC	4240					*	*				*				*			*	*							
LICI	209C					*	*				*				*			*	*							
MACF	3E84				*			*											*					*	*	
MACFIN	C			*	*	*		*			*				*			*	*			*				
MADE	4B04			*		*												*	*					*	*	
MAPR	12CC																		*				*	*	*	
MAPR1	976																		*				*			
MASSES	460					*	*	*	*		*		*	*	*				*		*		*			
MAX	2B98			*		*												*					*	*	*	
MCFIII	8		*	*	*	*			*		*				*			*	*		*		*			*
METPIN	290C			*		*		*			*				*			*	*							
NHIUGM	144							*			*				*				*							
NP00I2	320			*	*	*	*	*	*	*	*				*		*	*	*	*	*		*			
NP00I4	4			*	*	*	*	*	*	*	*				*		*	*	*	*	*		*	*	*	
NP00R8	4B0			*	*	*			*									*			*					
NP01I2	F0			*	*	*		*	*		*				*			*			*		*			
NP01R8	1C20			*		*	*		*									*			*		*	*	*	
NP02I2	780							*			*				*											
NP02R8	4B0				*		*	*	*		*				*		*			*	*					
OLEO	82C			*		*		*	*		*				*		*	*			*			*	*	
OTPLT	F72														*				*			*	*			
PPLTS	4CA										*				*								*			

TABLE 4-1. KRASH85 SUBROUTINE/COMMON REGION REFERENCE (CONTINUED)

SUBROUTINE		ACCELT	ACCEN	BEAM	CFORCE	DERIV	DOATJ	GENMOD	IC	ICINPT	INPRNT	INPRT1	INPT	INPTPL	INPUT	INTERP	KVB	LICALC	MAIN	MODXDP	NETFOR	PREPLT	PRINT	RSIN	RSOUT	SMLOAD
COMMON REGION	SIZE																									
PRALL	4																		*				*			
PRMA	2490			*		*												*	*				*	*	*	
PRNFAC	4B00																				*		*			
RESTRT	30			*		*					*				*			*	*							
SMLDS	1004										*				*											*
STUFF	3A0							*			*										*					
UB	70C			*		*		*			*				*		*	*	*							
UBICD	E10																*									
UBIUNA	258														*		*									
VARINT	40			*		*					*				*			*	*				*			
VBEAM	258			*		*	*	*			*						*	*					*			

REFERENCES

1. Gamon, M. A., "KRASH User's Manual; Theory Volume I," FAA-RD-77-189I, Lockheed-California Company, Sept. 1979

2. Gamon, M. A., Wittlin, G., "KRASH User's Manual, Input-Output, Techniques and Applications," Lockheed-California Company, FAA-RD-77-189II (Revised), Sept. 1979

APPENDIX A

SHOCK STRUT ELEMENT DESCRIPTION

A.1 GENERAL

The use of a shock strut element in KRASH is available for, but not limited to, lending gear oleo struts. The following discussion will be oriented to landing gear oleo strut usage. The axial strut motion is assumed to be uncoupled from the transverse displacements. Axial forces are produced by an air spring force, F_{A_i}, a hydraulic damping force, F_{O_i}, a friction force, F_{F_i}, and forces produced by elastic stops which limit the travel of the piston within the cylinder at full extension and full compression. Each of these forces is discussed separately.

A.2 AIR SPRING FORCE

The expression for the air spring force is

$$F_{A_i} = F_{AO_i} \left(\frac{E_i}{E_i - y_i} \right)^{n_i} - F_{AA_i} \tag{A.1}$$

where

E_i = effective total strut cylinder length (Figure A-1)

$F_{A_{O_i}}$ = strut air preload at $y_i = 0$

F_{AA_i} = cylinder load due to ambient air

n_i = polytropic exponent

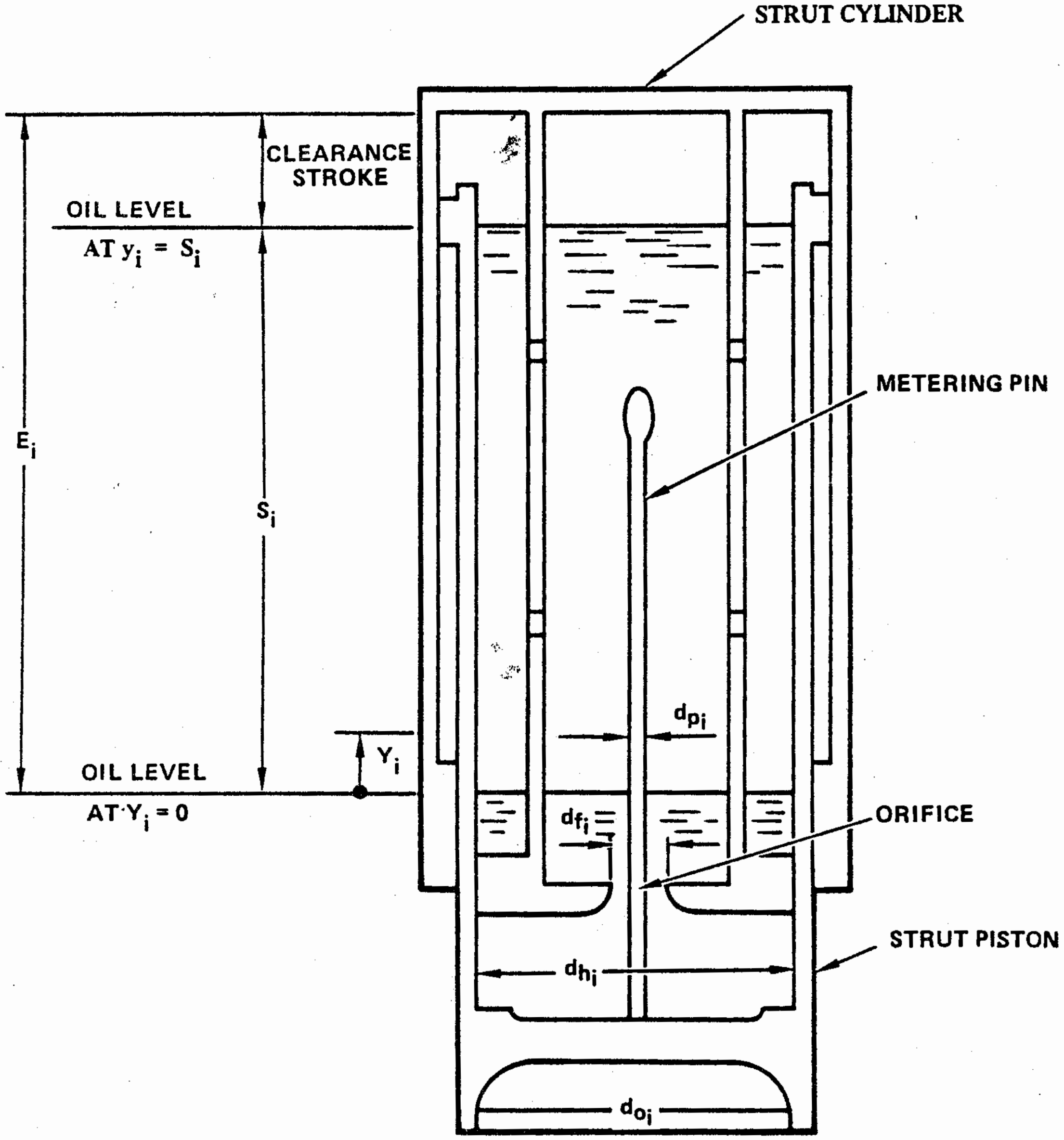


FIGURE A-1. SCHEMATIC OF OLEO STRUT

y_i = shock strut closure displacement, varying with time $F_{A_{o_i}}$ is given by

$$F_{A_{o_i}} = \pi/4 \left(p_{oi} \, d_{oi}^{\;2} \right) \tag{A.2}$$

where p_{oi} is the absolute air pressure in the upper chamber of the shock strut at full extension ($y_i = 0$) and d_{oi} is the effective pneumatic diameter as shown in Figure A.1.

If $F_{A_{s_i}}$ is the strut bottoming load at $y_i = s_i$, the value of E_i can be obtained from equation (A.1) as

$$E_i = \frac{S_i}{1 - \left(\dfrac{F_{A_{o_i}}}{F_{A_{s_i}} + F_{A_{A_i}}} \right)^{1/n_i}} \tag{A.3}$$

where S_i is the stroke. For high velocity impact conditions, a polytropic exponent of 1.4, representing adiabatic conditions, is appropriate.

In the program the values of E_I, $F_{A_{o_i}}$, $F_{A_{A_i}}$, S_i and n_i are input as EOLEO, FAO, FAA, YMAX and EXPOLE, respectively.

A.3 HYDRAULIC DAMPING

The hydraulic damping force F_{o_i} is given by

$$F_{o_i} = C_{z_i} \left| \dot{y}_i \right| \dot{y}_i \tag{A.4}$$

where

y_i = shock strut closure velocity, varying with time

$|y_i|$ is the absolute value of y_i and C_{z_i} is a damping constant which is a function of the strut orifice characteristics B_i and of the characteristics B_{r_i} of a strut rebound valve. C_{z_i} is defined as

$$\begin{aligned} C_{z_i} &= B_i \text{ if } \dot{y}_i \geq 0 \\ C_{z_i} &= B_i + B_{r_i} \text{ if } \dot{y}_i < 0 \end{aligned} \qquad (A.5)$$

B_i is defined by

$$B_i = \frac{\gamma A^3_{h_i}}{2g\ (A_{f_i} C_d)^2} \qquad (A.6)$$

where

$A_{f_i} = {}^{\pi}/4\ (d_{f_i}{}^2 - d_{p_i}{}^2)$ = net orifice area

C_d = orifice discharge coefficient (typical value = 0.85)

γ/g = oil density (typical value = 0.992 E-4 $\frac{\text{lb-sec}^2}{\text{in}^4}$)

$A_{h_i} = {}^{\pi}/4 \left(d_{h_i}{}^2 \right)$ = effective hydraulic area

d_{f_i}, d_{p_i} and d_{h_i} are the orifice, metering pin and effective hydraulic diameters, respective (see Figure A.1).

B_i and B_{r_i} are input into the program as BOLEO and BROLEO. A metering pin can be modeled by inputting a table of BOLEO versus YOLEO. YOLEO is the oleo compression, y, measured from the fully extended position.

Another feature of KRASH is the ability to solve for the metering pin shape that yields a desired oleo load-deflection characteristic curve. If this option is employed, the metering pin input table (POLEO versus YOLEO) is interpretted as a table of total axial oleo load (F_i in equation A.10) versus oleo compression. This option is termed the inverse metering pin option, and is employed by specifying a negative number for MPTAB on card 1400. The inverse metering pin coding is useful for two situations.

- Landing gear drop data are available, but the basic gear data (metering pin shape) is not. KRASH can be used to calculate the variation of BOLEO versus YOLEO that will duplicate the observed test data, which is used as input data with the inverse metering pin coding. Once the BOLEO vs YOLEO data is calculated and output by KRASH, it can be used as input data for subsequent runs to analyze different conditions involving that gear.
- Metering pin design studies can be conducted using KRASH with the inverse metering pin option. In this situation, a metering pin characteristic can be determined that will yield a specified ideal oleo load-deflection curve.

When the inverse metering pin option is employed, the KRASH output data includes a table of YOLEO vs. BOLEO for each oleo specified. The data point spacing for the table is determined by the output point times specified by DP/DT on card 110. The data will be output in uniform time steps, which means that the YOLEO increments will not be uniform.

A.4 FRICTION FORCE

Coulomb friction is modeled, so that the magnitude of the friction force is independent of velocity, while the direction of the force is opposite to the direction of the strut velocity.

The friction forces, F_{F_i}, are given by

$$F_{F_i} = C_i f(\dot{y}_i) \tag{A.7}$$

where $f(y_i)$ is a function whose sign is always equal to that of $\dot{y}_i$ and whose magnitude is 1.

Strictly speaking, $f(\dot{y}_i)$ should be equal to 1.0 for all positive values of $\dot{y}_i$ and equal to -1.0 for all negative values of $\dot{y}_i$. However, since the friction force is a passive force and is only present as a reaction to an applied force, the friction force will be able to attain its full value only if the applied force is greater than C_i. If this situation is not the case, stops will occur in the motion. A rigorous treatment of this problem would introduce unwarranted complications into the program. A very good approximate solution which avoids the difficulty can be obtained by letting the friction force vary sufficiently slowly from C_i to $-C_i$ at small values of $\dot{y}_i$, so that at each step in the integration process equilibrium of the forces is obtained without introducing large discontinuities. The following form is therefore assumed for $f(\dot{y}_i)$:

$$f(\dot{y}_i) = \tanh(\dot{y}_i/\alpha_o) \qquad (A.8)$$

This function is plotted in Figure A-2 for various values of α_o. The value of α_o should be small enough to simulate the friction force with sufficient accuracy, but not so small as to introduce discontinuities. The minimum value will depend on the integration interval. Generally a value of $\alpha_o = 1$ is found to be suitable. The expression for the friction force becomes

$$F_{F_i} = C_i \tanh(\dot{y}_i/\alpha_o) \qquad (A.9)$$

The values of α_o and C_i are input as ALPHAP and FCOUL in the program.

A.5 ELASTIC STOPS

Two elastic stops of stiffness K_{E_i} and K_{c_i} are present which limit the travel of the piston at full extension and full compression, respectively. The forces generated by these stops are, therefore, equal to $K_{E_i} Y_i$ when $y_i < 0$ and $K_{c_i} (y_i - S_i)$ when $y_i > S_i$.

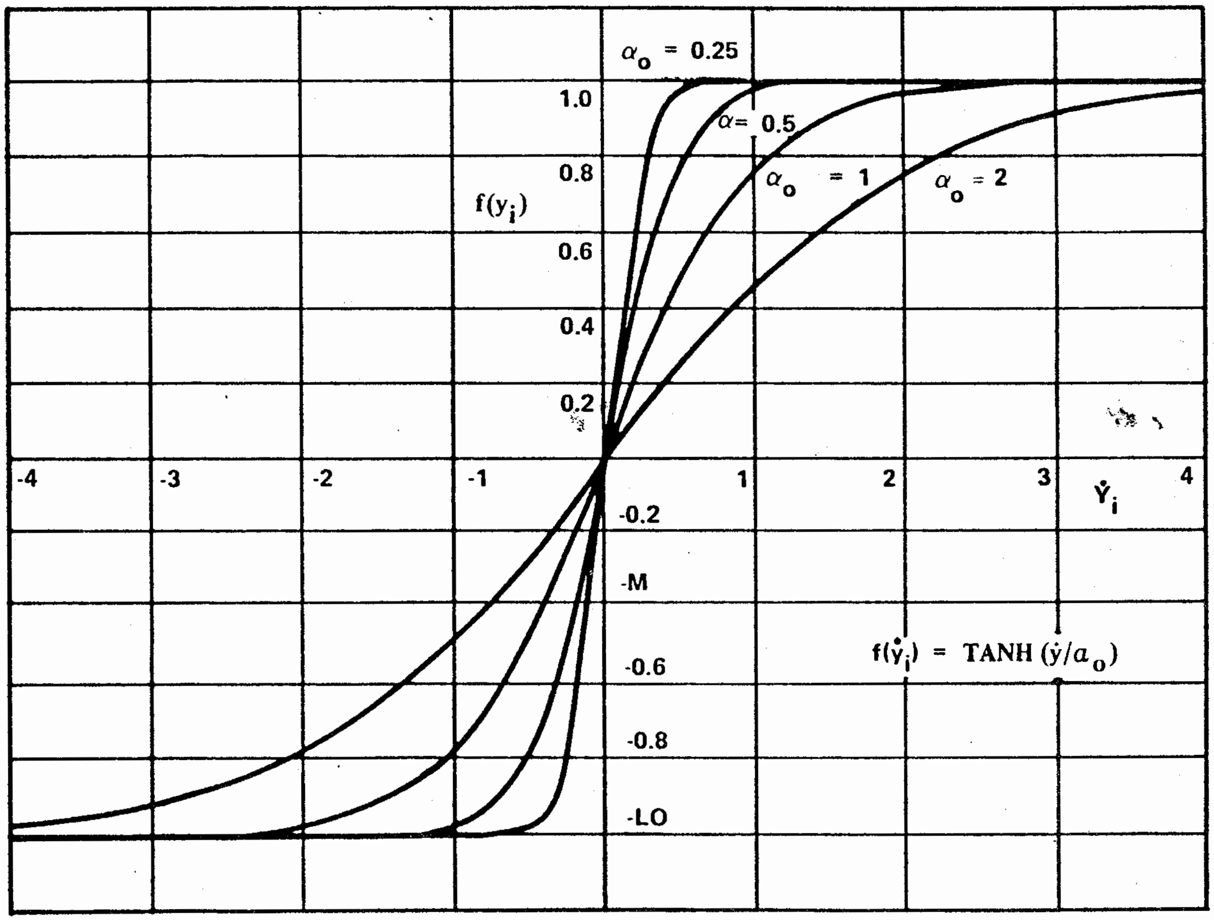


FIGURE A-2. FRICTION FORCE COEFFICIENT AS FUNCTION OF STRUT CLOSURE VELOCITY

Collecting all the above terms the total axial force F_i can be written as

$$F_i = F_{A_i} + F_{o_i} + F_{F_i} + F_{EXT_i} + F_{COMP_i} \qquad (A.10)$$

The terms K_{E_i}, K_{c_i}, and S_i are input into the program as XKEXT, XKCOMP, and YMAX, respectively.

APPENDIX B

STANDARD DISTRIBUTION LIST

Region Libraries

Alaska	AAL-64
Central	ACE-66
Eastern	AEA-62
Great Lakes	AGL-60
New England	ANE-40
Northwest-Mountain	ANM-60
Western-Pacific	AWP-60
Southern	ASO-63d
Southwest	ASW-40

Center Libraries

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Aeronautical Center	AAC-44.4

Civil Aviation Authority
Aviation House
129 Kingsway
London WC2B 6NN England

Embassy of Australia
Civil Air Attache
1601 Mass Ave. NW
Washington, D. C. 20036

Scientific & Tech. Info FAC
Attn: NASA Rep.
P.O. Box 8757 BWI Aprt
Baltimore, Md. 21240

DOT-FAA AEU-500
American Embassy
APO New York, N. Y. 09667

Headquarters (Wash. DC)

ADL-1
ADL-32 (North)
APM-1
APM-13 (Nigro)
ALG-300
APA-300
API-19
AAT-1
AWS-1
AES-3

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M-493.2 (Bldg. 10A)

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Berkely, CA 94720

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Civil Air Attache ATS
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Washington, DC 20008

Dir. DuCentre Exp DE LA
Navigation Aerineene
941 Orly, France

Northwestern University
Trisnet Repository
Transportation Center Lib.
Evanston, Ill. 60201

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FAA, Mike Monroney Aeronautical Center, P.O. Box 25082, Oaklohoma City, OK 73125 (Attn: Richard Chandler, AAM-119)	(1)
NASA, Langley Research Center, Hampton, VA 23365 (Attn: Emilio Alfaro-Bou, MA-495; Huey Cardin, MS-495)	(2)
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Boeing Co., Vertol Division, P.O. Box 16858, Philadelphia, PA 91942 (Attn: Denise Vassilakos, MS P30-27)	(1)
Cessna Aircraft Co., P.O. Box 7704, Wichita, KS 67277 (Attn: John Berwick; Robert Held; Richard Soloski)	(3)
Fairchild Aircraft Corp., P.O. Box 3246, San Antonio, TX 78284 (Attn: Walt Dwyer)	(1)
General Dynamics/Convair, P.O. Box 80847, San Diego, CA 92138 (Attn: L. Mastny, MA 80-6030)	(1)
Grumman Aerospace Corp., So. Oyster Bay Road,, Bethpage, L.I., NY 11714 (Attn: Robert Winter, A08-35; Allan B. Difko, A08-35)	(2)

Gulfstream Aerospace Corp., P.O. Box 2206, Savannah, GA 31402 (1)
(Attn: George Westphal)

Gulfstream Aerospace Corp., P.O. Box 22500, Oklhoma City, OK 73123 (1)
(Attn: Richard Southard)

Lockheed-California Co., Burbank, CA 91503 (1)
(Attn: Gil Wittlin, D 76-12, B 63G, PLT A-1)

McDonnell Douglas Corp., 3855 Lakewood Drive, Long Beach, CA 90846 (2)
(Attn: J. Webster; John L. Galligher)

McDonnell Douglas Helicopter, 4645 S. Ash Ave., Tempe, AZ 85182 (2)
(Attn: Lyndon Landborne; J.K. Sen)

Piper Aircraft Corp., 2925 Piper Drive, Vero Beach, FL 32960 (1)
(Attn: Marion Dees)

Sikorsky Aircraft, North Maint Street, Stratford, CT 06601 (2)
(Attn: Brain Cornell, MS 5207A; Pramonik Mukunda, MS 5207A)

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